BUREAU OF NAVIGATION—HYDROGRAPHIC OFFICE.

PAPERS

ON

THE EASTERN AND NORTHERN EXTENSIONS

OF

THE GULF STREAM.

FROM THE GERMAN OF

DR. A. PETERMANN, DR. W. VON FREEDEN, AND DR. A. MÜHRY.

TRANSLATED IN THE UNITED STATES HYDROGRAPHIC OFFICE,
IN CHARGE OF CAPTAIN R. H. WYMAN, U. S. N.,

BY

E. R. KNORR.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1871.

GC456
.G945

HYDROGRAPHIC OFFICE,
Washington, D. C., November 1870.

The valuable papers of Doctors Petermann, Von Freeden, and Mühry, on the eastern and northern extension of the Gulf Stream, are republished in translation; not only for the fund of information they contain, of interest both to science and to shipping, and especially to whalers and seal-fishers, but also, for the purpose of promoting the coöperation of the latter in the investigation of the relation of the currents and temperature of the northern seas.

It will be seen on the accompanying charts that comparatively few observations have been made, thus far, to the north of the ordinary routes between the United States and Great Britain. In those more northern fields the whaling fleet is engaged at all times, frequently wintering there, and their masters have ample opportunities for making valuable observations, as, being on the spot, they are able to take advantage of those favorable openings which are so rare, and for which expeditions, sent out especially, have waited in vain.

The Hydrographic Office will cheerfully receive any records and make the most appropriate use of them, giving due credit to the contributors.

Information, as regards the observations required, the forms for records, &c., will be found in the following pages. The instruments used should, on the return, be compared with standards, and a full description of them sent, with the record, in order that the observations may be properly reduced.

The temperatures, in the German text and on the original maps, were according to Réaumur; they have been reduced to Fahrenheit; the decimals have been dropped, and the nearest whole degree substituted to prevent crowding the maps. In the text they have been retained only where necessary.

The figures of reference in the text refer to the notes which will be found at the end of the work. These have been given in full, where the references were in the German language, or where the books referred to are difficult to obtain.

The remarks printed within brackets are by the Hydrographic Office.

R. H. WYMAN,
Captain U. S. N.,
in charge of Hydrographic Office.

CONTENTS.

PAPER I.

PAPER II.

PAPER III.

IV.—FIRST APPENDIX.

VI.—SECOND APPENDIX.

I.

THE GULF STREAM,

AND THE

KNOWLEDGE OF THE THERMAL PROPERTIES OF THE NORTH ATLANTIC OCEAN AND ITS CONTINENTAL BORDERS, UP TO 1870.

(WITH TWO CHARTS.)

By AUGUSTUS PETERMANN.

FROM THE "MITTHEILUNGEN," BY THE GEOGRAPHICAL INSTITUTE OF JUSTUS PERTHES, 16TH VOLUME, 1870, PARTS VI AND VII.

1.—INTRODUCTION.

Five years ago, when urging the exploration of the polar regions, I took occasion to review briefly the oceanic currents, especially the Gulf Stream.[1]

Until then the Gulf Stream generally was represented, on charts and in the various text-books, as extending only to about the 45th degree of northern latitude, turning there toward the African coast; the conception and the knowledge of it was confined almost exclusively to that southern portion of the system of North Atlantic currents.

My own ideas, in 1865, of the extent and of the immense volume of the Gulf Stream I expressed as follows:

> Instead of a weak and insignificant drift from Newfoundland toward Europe, as heretofore represented, I consider the northern part of the Gulf Stream one of the mightiest currents of the world, although comparatively but slow, not very perceptible on the surface of the ocean, and therefore of no great moment to navigation. I do so, because ocean currents have to perform yet other functions than merely those of a strong surface stream. In that view I conceive the Gulf Stream to be a deep, permanently warm current from Newfoundland to the coasts of France, Great Britain, Scandinavia, and Iceland, up to Bear Island, Jan-Mayen, and Spitzbergen; and along the western coast of the latter up to the 80th degree of north latitude, thence to Nova Zembla into the Polar Sea; passing the northernmost capes of Siberia and the New Siberian Islands, where it appears on the charts as the Polynja of the Russians, discovered by Hedenström sixty years ago, and fully corroborated by Wrangell and Anjou, its influence being felt perceptibly even as far east as Cape Jakan. We were the first, I believe, who attributed to the Gulf Stream so mighty an extent and showed it as such on our charts thirteen years ago, when addressing the late hydrographer of the British Admiralty, Sir Francis Beaufort, in a paper which was printed by order of the British Parliament.[2]

On that occasion I traced in detail the wonderful and grand influence of the Gulf Stream from Newfoundland up to Cape Jakan in the vicinity of the Behring Strait.[3]

In two monographs, published since, "The Northernmost Land of the Globe," and "The Expeditions to the Arctic Ocean north of Behring Strait, 1648 to 1867," I have traced a branch of the Gulf Stream up to Smith's Sound and another warm current from the Pacific Ocean through Behring Strait up to the polar land discovered by Kellett and Long.[4]

Although, since 1865, high authorities have pronounced against my theory of the extent and the volume of the Gulf Stream, I cannot but still maintain the same, and shall now produce the figures of actual observations, on which it is based, and without which we but drift into arbitrary suppositions.

Before doing so, however, I shall refer to a few of the numerous objections raised against it.

Mr. A. G. Findlay, the meritorious English hydrographer, in a discourse before the Geographical Society of London, held February 5, 1869, maintained that the Gulf Stream proper, discharging through the Florida Straits, has not sufficient width and depth to reach the coasts of Europe, or to affect the climate of the latter, as with its diminishing velocity it would require one or two years to come over to Europe, during which time the temperature of the water would become too low to exercise any influence; further, that the Gulf Stream, after having reached Newfoundland, is totally annihilated by the Polar Stream, and is not perceptible beyond; that the mild climate of Northwestern Europe cannot be attributed to the Gulf Stream, but results from the general drift of the North Atlantic Ocean, and that the currents near Europe should be designated as such and named accordingly.[5]

That the Gulf Stream, in its course toward Europe, receives and unites with a drift corresponding in direction, is probable and natural; but it is equally certain that the former is the main body or the principal stream of the general movement of the North Atlantic waters at all times of the year, as proved most positively by Maury's thermal charts.

Of continental rivers the expression is used that they have their source or head and their mouth, but this does not imply that all the water emptying at the mouth comes exclusively from the small source. The Florida Stream may be compared with the head of a great river which is swelled, in its course to the mouth, by tributaries. In the same manner, then, as a great river basin is named from the principal river, it appears proper and to the purpose to retain for the warm North Atlantic current the name "Gulf Stream." It surely would be difficult to ascertain where the Florida Stream ceases really, where it receives tributaries, and how many, and what part of the temperature of the combined stream is ascribable to the Florida Stream, and what to the tributaries. The name "Gulf Stream" has been adopted so generally for the great oceanic current which bathes the European shores that it would rather be better to call the head and the first part of the course "Florida Stream," than to use for the other part a new and complicated name, instead of one long known and now used throughout.

In regard to the essential features, the inherent qualities of the stream, I refer, for the present, to the two accompanying charts. In Findlay's chart of the Gulf Stream,[6] the stream terminates between the 40th and 45th degrees of northern latitude and near the 45th degree of longitude west of Greenwich. I leave it to be inferred from my charts how far that can be justified.

Findlay, however, does not deny the extension of a warm current to Europe, and this is and remains the main point. But Messrs. Carpenter and Jeffreys, the scientific gentlemen of the two British expeditions for deep-sea sounding, deny it distinctly.

William B. Carpenter leaves it an unsolved question whether the higher temperature of the North Atlantic, near the coasts of Scotland and Ireland, is exclusively solar, (caused by the sun,) or whether it results, more or less, from the Gulf Stream.[7] He says:

> The influences of the Gulf Stream proper, (meaning by this the body of superheated waters which issues through the "Narrows" from the Gulf of Mexico,) if it reaches this locality at all, which is very doubtful, could only affect the most superficial stratum; and the same may be said of the surface-drift caused by the prevalence of southwesterly winds.

Jeffreys is of opinion that the mollusca of this part of the ocean are mostly arctic or northern species, which would disprove the theory of the Gulf Stream's reaching to the coasts of Ireland and Scotland.[9]

The expedition, however, ascertained the temperature of the water, at a depth of 1,000 fathoms, to be 38°.1, and at 2435 fathoms, still 36°.5. Compared with this, the deep-sea temperature of the Gulf of Arabia, and even of the waters under the Equator, will be found very low, sinking to 34°; in general the deep-sea temperature of the tropical oceans is lower than that of the North Atlantic basin.[10]

The upper warm stratum of the North Atlantic Ocean, between Ireland and the Faroes, was, from the soundings of the two British expeditions of Carpenter, computed to have a depth and width of not less than 700 to 800 fathoms,[11] which, of course, excludes the idea of a drift or surface current, and most strongly fortifies the theory of a deep, voluminous, warm stream. Therefore Carpenter and Jeffreys, while denying the extension of the Gulf Stream into those latitudes, produce the strongest evidence against their own assumption.

In the United States of America, also, where Maury has earned the thanks of mankind for his great labors toward the better knowledge of the oceans, voices have been raised lately against the extension of the Gulf

Stream beyond the approximate middle of the North Atlantic, the 40th degree of longitude west of Greenwich. Hon. Charles Daly, the president of the American Geographical and Statistical Society, in his annual address of January 25 says:

With the view of ascertaining what we really know respecting the velocity and course of the Gulf Stream, I applied to one of the oldest members of the society, G. W. Blunt, esq., whom, as the head of the well-known house that has, for nearly a century, prepared and published the charts that have guided the American mariner in every quarter of the globe, I considered the most competent person, with whom I was acquainted, to furnish the information. I submit his reply:

"*December* 22, 1869.—I send you my North Atlantic memoir, which contains all the accurate information (I am sorry to say, not a great deal) about that much misrepresented current of the ocean, the Gulf Stream, which body has to bear with the inventions of Maury, the stupidities of weather predictors, and the assumptions of meteorologists, enough, either of them, to crush out the vitality of anything which has not so perfect an organization as the Gulf Stream has. The only accurate observations we have of the Gulf Stream are those of the United States Coast Survey, directed by Professor A. D. Bache. * * * * * Beyond the Western Islands, I believe the Gulf Stream has no existence, and that the alleged effects of it on the climate of the British Islands are due to the assertions of the class I have spoken of in the first paragraph of my letter. * * * * The Gulf Stream, as a current, I believe, entirely ceases and loses all its equatorial heat to the eastward of the longitude of 40 degrees; the set to the east is that of the general set of the North Atlantic, and the temperature of the water is that of the general temperature in those regions." [12]

So much has of late been written against the Gulf Stream, or against its extension toward Europe, that influential journals of England, circulating in educated society, put down the entire subject as a humbug.[13]

In Germany a better knowledge of the Gulf Stream is now firmly established. The various charts of the world by Dr. Hermann Berghaus, especially his great chart and his small Mercator's chart, showing the currents, in Stieler's Atlas, (No. 9,) are the best and most accurate representations existing of the oceanic currents, and contain more valuable and reliable information about them than everything else which has been written thus far. The memoirs of Dr. Adolf Mühry, among others his latest, "The Theory of Oceanic Currents, Göttingen, 1869," are at the head of text-books.

There still are, however, authors in Germany who plead for the views of Findlay or Blunt. Dr. H. Romberg, in a lecture, delivered February 15, 1870, before the Society of Natural Sciences of Bremen, on the subject of oceanic currents, and on Dr. Mühry's memoir, just cited, pronounced "that the importance of the Gulf Stream to the climate of Europe appears to him to be overrated, and that probably a drift, more than the Gulf Stream, carries the warm waters toward the coasts of Western Europe."[14] A single glance at my two charts will show that, on the contrary, this influence has heretofore been *underrated.* The "History of the Gulf Stream," by J. G. Kohl, and the latter's views, are characterized most conclusively by the closing passage of the book. It is said there:

All late hydrographers have represented the Gulf Stream the same as Findlay, partly on his authority. The picture he draws of it, which also has been reproduced on the chart of the Atlantic currents accompanying Captain A. B. Beecher's book on the navigation of the Atlantic Ocean, may well serve as a type of the theories adopted of late in regard to the extent of the Gulf Stream.[15]

According to Kohl, Mr. Findlay is assuming the Gulf Stream to proceed around North Cape, "along the coast of Siberia, and along the Arctic archipelego of North America, (revolving around the North Pole,) and thence through Davis's Strait into Baffin's Bay, back again into the Atlantic Ocean."[15]

There can be no stronger contradiction and more positive protest against this assertion than the memoir of Findlay, published February 8, 1869, in which he cuts off the Gulf Stream on the meridian of 45° W. of Greenwich, going back even to the time before Rennell, who already, in 1832, had produced it to the Azores, beyond the 30th degree west of Greenwich, bending it there toward the south, in which there is at least common sense; while it is contrary to the laws of nature to cut it off, without any motive, in the middle of the ocean, as Findlay has done in his latest chart.[16]

Kohl, in his memoir of 1868, ignores the most important authorities for the Gulf Stream; for instance, Maury's thermal charts of 1852, Andrau's "Onderzoekingen mit den Zee Thermometer, 1861," and a series of observations and explorations north of the regions discussed by the above. Stations for the observation of the temperature of the sea existed there before 1868; for instance, at Reikiavik since May, 1832, and those of the Scottish Meteorological Society, extending as high as Stykkisholmr in Iceland.

Kohl contends "that, up to 1868, all the operations in the Gulf Stream had been carried on in summer time, and that, therefore, but very little is known of the temperature and the other properties of the stream during the winter months."[17] A glance at the chart, "The Gulf Stream in Winter," will show how ill founded this assertion is, since most of the observations recorded on its face did exist before 1868. Maury's thermal charts, published 1852, contain thousands of good observations; Andrau's "Onderzoekingen" of 1861, (pages 7, 8, and 18,) give alone for the three winter months, December, January, and February, the mean values of 8,176 single observations in the Atlantic Ocean, up to 49° N. latitude.

The three charts accompanying Kohl's book extend not further north and east than 47½° N. (south coast of Newfoundland) and 30° W. of Greenwich, (the Azores.)

To sum up, there has been too much written about the Gulf Stream, while too little has been shown by charts.

2.—CONSTRUCTION OF THE TWO ACCOMPANYING CHARTS, "THE GULF STREAM IN THE SUMMER, (JULY,) AND IN THE WINTER, (JANUARY,)"—AUTHORITIES.

My current chart of 1865[18] represented the currents of the globe, with the exception of the equatorial belt between 20° N. and 20° S. latitude; and my conception of them, at that time, has, in the main, been proved correct by the subsequent researches and observations. The two new charts of the Gulf Stream, accompanying this, are intended to show it on a scale about thrice as large, and to exhibit the proofs for the correctness of the representation by the figures actually observed and the curves constructed from them. These figures, however, are only a selection from the many on my large working sheets, which embrace all the months of the year; while the limits of this periodical permit to be represented only the two culmination months, July and January.

On the charts the Gulf Stream may be traced from step to step by hundreds of figures, expressing the mean values of many hundred thousand single observations. To do so unbiased, it will be well to cast loose from the theories of Rennell, Findlay, and others, which, for thirty-eight years, have been in the way of a correct conception of the Gulf Stream phenomenon.

The most important authorities for the Gulf Stream have been, during the last eighteen years, and still are, the wind and current charts of the North Atlantic, prepared, under the direction of Lieutenant Maury, at the United States Naval Observatory, and published by the Government of the United States,[19] on which the observations for the temperature of the surface of the ocean, made on board of a very great number of ships, are recorded in a manner so as to distinguish between the figures for each of the twelve months of the year by their color, their size, and by the way of their being printed, (upright, slanting, or reversed,) which, however, is quite difficult. The eight sheets contain not less than 27,485 figures, which, in many places, are printed not only very close but even over each other in the various colors; thus creating a confusion, which is still further aggravated by the addition of a number of isothermal lines, denoting the temperature for every ten degrees in each month. No one has ever yet, to my knowledge, taken the pains to make an exhaustive use of all the figures on these sheets.

Professor Schmid, in his excellent and very complete "Compendium of Meteorology,"[20] reproduces the isothermal curves of Maury on twelve charts, one for each month, without any figures of observation, and takes occasion to criticise Maury's thermal charts as follows:

> The more rich the material, the less clear is the representation. In fact, even with great attention and aided by a good eye sight, it is difficult to find the way through the mass of figures and lines, and it is much to be regretted that there is not a table of figures appended to the graphical representation, adding clearness to accuracy and precision. The inflections of the isothermal lines are so very sinuous that one rather sees in them accidental deviations of some single observations than the probability of a general mean value; the waters of the ocean are too agitable, and, in the whole, too much agitated, to look for rigidly-defined lines, expressing the relations of the various parts toward each other.

In constructing charts everything depends upon a sound generalization, answering the purpose. If, for a general chart, one should but accurately copy the topographical charts of the various parts, the representation of the whole would be very defective, wanting especially in general characteristics. Still worse would be an isothermal chart, if it were attempted to have regard to every elevation of a few hundred feet, which influences the temperature; a complete labyrinth of lines, from which comparatively nothing could be derived, would be the result.

Maury's isothermal lines do not show the substance and do not convey a clear representation of his valuable figures. I have constructed, therefore, from the latter, new isothermal lines, representing as accurately as possible mean values of the temperature of the ocean. Most of the small differences, in detail, may result from the extent allotted to the monthly period, as it is probable that the observations obtained on the 31st of July agree better with those of August 1, than with those of July 1.

The second principal source of the knowledge of the Gulf Stream is "The Observations of Dutch Navigators," published at the expense of the Netherland Government, 1861.[21] But, while Maury's figures go beyond the

60th degree of north latitude, these reach only to the 49th degree, and are, besides, only the deduced mean values, and not, as on Maury's charts, the actually observed figures. The Atlantic Ocean has been, for that purpose, partitioned into squares of one degree of latitude and five degrees of longitude, and the mean is taken of all the observations in each of them and recorded. On my chart I have designated them as "Andrau's mean values," the chief of the Royal Netherland Meteorological Institute in the Navy Department, Lieutenant Andrau, of the Netherland navy, having prepared the book.

These mean values are given in twelve tables, and represent 44,747 observations, viz., 3,477 for January, 2,049 for February, 3,534 for March, 3,566 for April, 3,771 for May, 4,550 for June, 3,742 for July, 4,837 for August, 3,840 for September, 3,241 for October, 5,490 for November, and 2,650 for December. There are added also four isothermal charts, two for February and August, and two others for the means of February and March together, and for the means of August and September together, showing the isothermal lines for every five degrees Celsius, in some parts for every degree.

On my charts Andrau's mean values occupy principally the southeastern part of the North Atlantic Ocean from the West European coast to the Azores, and beyond them; on the whole they agree excellently with Maury's figures, from which they are distinguished on the charts by difference in the type.

For the part of the ocean from 50° to 55° N. latitude, already so well provided for by Maury and Andrau, there are also various other series of observations, for instance, the report of the British Meteorological Institute, "Non-official, No. 2,"[22] but the figures on which these are based are represented by diagrams in profile, and cannot be deduced with accuracy from them. Moreover, the results of Maury's and Andrau's figures are not likely to be changed materially by additional data.

There are, further, the "Mean Values" of Whitley,[23] from the observations during five years on board of the vessels of the Cunard Steamship Line between Liverpool and New York, from which the monthly means are computed for each five degrees of longitude. A table of these means has already been published in the "Geographische Mittheilungen."[24]

To use these mean values for isothermal charts would not only be of no profit, but they might, besides annoying, actually corrupt the other data, as there is only the longitude recorded for position and not the latitude; if the latter is deduced from the average course of the steamers, the values for temperature are evidently too high; the ships, in fact, deviate on their various trips too much from the average course, as testified by the more complete records of the vessels of the Montreal Ocean Steamship Company, plying between Glasgow and Liverpool, and the Strait of Belle-Isle.

Of the results of the various local observations by Whitley, in the sea around the British Isles, I will mention as of interest only the mean temperature on the line "Hull to Hamburg," for January 1869, which is 43.°

Of the observations which have been made north of Maury's and Andrau's fields, those by the Scottish Meteorological Society and the Norwegian Meteorological Institute, since January 1857, are by far the most important, marking a new epoch in the history of the Gulf Stream. They are carried on during the entire year, in each month of it, at fixed points of the coast, and embrace Scotland, the Orkney Islands, Shetland, Iceland, and Norway up to Fruholmen in 71° 06′ N. latitude, in the vicinity of the North Cape.

Alexander Buchan, the secretary of the Scottish Society, in a most valuable monograph "On the Temperature of the Sea on the Coast of Scotland," published 1865, reviewed minutely what the Scottish Meteorological Society had done so far for oceanic meteorology with its own private means.[25] That memoir is, in various respects, the most important existing on the temperature of the ocean. The author arrives at the conclusion *that the sea around Scotland constitutes a part of the Gulf Stream.* He says:

> A line drawn from Cuba across the Atlantic Ocean to the Faroe Islands traverses water of a higher temperature than can be found east and west of it, and indicates a northerly current in that direction.[26]

The following are the monthly mean values and the extremes observed at the ten Scottish stations. On the two charts they, as also those of Iceland and Norway, are marked by different type and dots in red color; the seas west of Oban and Trinity are omitted, as of less importance and for want of space.

Sea temperatures, at the depth of 6 feet, at ten stations on the coast of Scotland, January 1857 to August 1865, and 1869.[27]

Station.	No. of years.	Mean temperature.												Highest and lowest temperature observed.		
		Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Max.	Min.	Diff.
		°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
West coast: Sandwick	12½	45.0	43.7	43.2	44.1	47.1	50.2	53.1	55.0	55.0	53.1	49.5	46.8	57.0	41.4	15.6
Stornoway	12	44.6	44.1	44.1	46.2	49.5	52.0	55.6	55.4	55.0	51.6	48.4	46.0	58.1	40.1	18.0
Harris	5	44.6	43.5	43.5	44.6	48.0	51.8	54.7	55.4	54.3	51.6	48.2	46.4	58.5	39.0	19.5
Oban	5½	45.0	43.7	43.0	44.4	47.3	51.3	53.8	55.2	54.7	52.9	49.8	47.1	59.2	41.9	17.3
Sea west of Oban	5	......	......	......	......	47.3	51.3	53.8	55.2	54.5	......	......	......	59.9	......	......
Otter-house	6¾	44.4	42.8	43.5	45.7	49.1	52.5	54.7	55.0	54.0	50.9	48.2	46.2	61.5	40.5	21.0
East coast: Westhaven	8½	41.2	40.5	42.3	46.2	50.0	55.0	57.4	58.3	56.5	49.8	45.0	43.2	63.0	36.5	26.5
North Berwick	4¼	41.4	40.5	41.2	43.7	48.0	52.9	56.1	56.5	56.3	51.8	47.5	43.2	59.9	36.9	23.0
Dunbar	8	41.4	40.3	41.0	44.1	48.6	52.2	55.6	56.3	55.2	51.1	46.6	43.9	59.9	36.9	23.0
Mean of west coast	6½	44.6	43.5	43.5	45.0	47.8	51.6	54.3	55.2	54.5	51.8	48.9	46.6	61.5	39.0	22.5
Mean of east coast	7	41.4	40.5	41.4	44.6	48.9	53.4	56.3	57.0	55.8	50.9	46.4	43.5	63.0	33.5	29.5
Trinity, chain pier	1½	39.2	36.5	38.7	43.7	49.1	53.6	56.1	56.3	53.6	49.5	44.8	43.7	59.9	33.6	26.3

The observations at East Yell for the Shetland Islands, for January, which were omitted by Buchan, I have also made use of for my chart, deeming them very important. The monthly mean for January is 45°.7.[28]

Mr. Buchan has had the goodness to send me the following details embracing the results of the observations at the stations of the Scottish Society in Iceland and the Faroes, up to October 1869.[29]

Mean temperature of sea and air at the stations of the Scottish Meteorological Society on Iceland and the Faroes.

SEA TEMPERATURE.

STYKKISHOLMR, ICELAND, (LATITUDE 65° 4′ N., LONGITUDE 22° 43′ W. OF GREENWICH.)

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
	°	°	°	°	°	°	°	°	°	°	°	°
1866	......	......	......	......	......	......	......	......	......	43.2	35.8	34.5
1867	30.4	30.2	31.1	30.6	36.7	43.9	49.8	50.0	47.7	44.1	41.2	37.2
1868	35.1	31.3	30.6	35.8	41.7	46.4	50.4	49.1	48.0	42.3	39.6	37.2
1869	36.7	31.8	......	......	......	......	......	......	......	......	......	......
Mean	34.0	31.1	30.9	33.1	39.2	45.1	50.0	49.5	47.8	43.2	39.0	36.3

REIKIAVIK, ICELAND.

1866	......	......	......	......	......	......	......	50.4	47.7	44.4	38.1	35.8
1867	30.4	31.1	32.9	35.4	42.8	47.3	52.9	51.1	49.1	44.6	41.4	39.0
1868	34.7	30.9	31.8	34.7	45.3	47.1	48.0	49.1	46.4	37.2	36.0	35.4
1869	34.7	33.1	35.4	38.7	42.1	46.2	......	......	......	......	......	......
Mean	33.3	31.7	33.4	36.3	43.5	46.8	50.4	50.2	47.7	42.1	38.5	36.7

THORSHAVN, FAROES, (LATITUDE 62° 2′ N., LONGITUDE 6° 43′ W. OF GREENWICH.)

1866	......	......	......	......	......	......	......	......	......	......	43.5	43.9
1867	41.2	43.5	41.0	40.6	44.1	45.0	48.6	49.8	49.3	47.3	46.2	45.3
1868	42.6	40.6	41.0	42.1	44.6	48.4	49.8	50.0	48.4	46.2	45.3	44.4
1869	42.3	40.3	40.8	41.9	44.6	46.0	48.2	49.8	......	......	......	......
Mean	42.1	41.4	41.0	41.4	44.4	46.4	48.9	49.9	48.9	46.7	45.0	44.6

TEMPERATURE OF THE AIR.

Stykkisholmr. Elevation, 37 feet.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
	°	°	°	°	°	°	°	°	°	°	°	°
1866	17.1	13.3	12.4	29.5	30.4	41.4	44.4	43.0	37.2	36.3	26.4	23.9
1867	18.0	23.4	23.7	26.4	36.5	43.9	48.4	47.3	43.9	37.2	36.5	32.7
1868	29.7	21.9	26.8	36.0	40.1	43.7	48.0	45.3	44.4	34.7	35.1	32.0
1869	33.1	23.2	......	......	......	......	......	......	......	......	......	......
Mean	24.6	20.5	21.0	30.6	35.6	43.0	46.8	45.3	41.9	36.1	32.7	29.5

Reikiavik. Elevation, 10 feet.

1866	......	......	......	......	......	......	......	......	......	......	31.8	30.0
1867	21.9	27.7	27.5	33.1	42.8	48.0	52.2	50.9	48.0	39.9	38.3	33.1
1868	31.8	23.7	27.7	38.3	45.3	45.5	50.0	48.4	45.5	35.1	36.5	32.7
1869	34.7	26.5	26.8	34.5	41.7	46.6	......	......	......	......	......	......
Mean	29.5	25.9	27.3	35.4	43.3	46.6	51.1	49.6	46.7	37.5	35.4	32.0

Thorshavn. Elevation, 12 feet.

1866	......	......	......	......	......	......	......	......	......	......	37.6	39.2
1867	32.0	38.5	34.5	41.9	42.8	49.1	51.1	52.7	50.9	45.1	42.1	37.4
1868	37.8	34.7	38.3	41.2	46.2	49.3	51.8	50.9	46.6	41.9	36.5	37.9
1869	41.2	36.5	33.6	39.0	40.6	47.3	50.7	50.2	......	......	......	......
Mean	37.1	36.5	35.4	40.7	43.2	48.6	51.2	51.3	48.7	43.5	38.7	38.1

Besides these, there exist for Reikiavik the observations of Dr. Thorsteinson,[30] which I even prefer to those of the Scottish stations, as they extend over a far greater period—20 to 22 years.

The differences, in the mean values, between the latter and the observations of the Scottish Society, which only extend over three years, will be seen from the following:

Authorities.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Thorsteinson	34.7	34.2	36.0	37.2	44.6	49.3	52.9	49.1	46.0	40.6	37.2	35.8
Buchan	33.3	31.7	33.4	36.3	43.5	46.8	50.4	50.2	47.7	42.1	38.5	36.7

Dr. Thorsteinson's observations of the temperature of the sea at Reikiavik.

Months.	Monthly mean values.	Number of years.	Number of observations.	Highest observed temperature.	Date.	Lowest observed temperature.	Date.
	°			°		°	
January	34.7	20	168	46	1833	30	1848
February	34.2	20	142	43	1841	31	1844
March	36.0	20	139	44	1851	31	1851
April	37.2	21	144	48	1833	32	1836, 1837
May	44.6	21	189	50	1833, 1834, 1838, 1842	37	1851
June	49.3	21	223	57	1833, 1843	41	1836
July	52.9	22	263	61	1833, 1843	47	1836
August	49.1	22	262	61	1843	43	1836
September	46.0	21	253	56	1843, 1852	39	1836
October	40.6	21	237	48	1838, 1842	29	1843
November	37.2	21	195	56	1844	29	1832
December	35.8	20	156	42	1840	31	1848

Observations of the temperature of the sea on the coast of Norway, by the Norwegian Meteorological Institute.

FRUHOLMEN, LATITUDE 71° 5¾′ N., LONGITUDE 23° 59½′ E. OF GREENWICH.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual mean.
	°	°	°	°	°	°	°	°	°	°	°	°	
1867	......	......	......	......	......	......	......	......	44.1	43.0	40.3	37.8	....
1868	36.0	35.1	35.6	37.4	37.6	42.6	45.5	48.4	47.1	44.8	42.6	39.2	....
1869	39.6	37.8	38.1	37.9	39.4	43.2	47.7	47.3	......	......	......	......	....
Mean	37.8	36.5	36.8	37.6	38.5	42.9	46.1	47.8	45.6	43.9	41.4	38.5	41.0

ANDENNES, LATITUDE 69° 19′ 30″ N., LONGITUDE 16° 8′ 10″ E. OF GREENWICH.

1867	......	......	......	......	......	......	47.3	50.2	46.8	40.5	34.3	32.4	....
1868	31.3	31.3	34.0	38.7	44.4	49.3	52.0	54.7	49.1	43.2	39.6	35.4	....
1869	37.6	35.1	34.5	38.1	43.0	49.5	52.3	50.9	47.8	......	......	......	....
Mean	34.5	33.2	34.2	38.4	43.7	49.4	50.5	52.0	47.9	41.9	36.9	33.9	41.4

VILLA, LATITUDE 64° 32′ 50″ N., LONGITUDE 10° 42′ E. OF GREENWICH.

1867	......	......	......	......	......	......	52.0	54.0	51.4	44.6	40.6	33.1	....
1868	34.0	36.0	36.7	39.9	47.1	50.7	55.8	58.1	51.6	43.0	39.6	37.2	....
1869	37.0	36.0	35.4	39.9	44.4	49.1	53.6	53.6	50.4	......	......	......	....
Mean	35.5	36.0	36.0	39.9	45.7	49.8	53.8	55.2	51.1	43.8	40.1	35.1	43.5

Observations of the temperature of the sea on the coast of Norway, &c.—Continued.

ONA, LATITUDE 62° 52′ 40″ N., LONGITUDE 6° 32′ 45″ E. OF GREENWICH.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual mean.
	°	°	°	°	°	°	°	°	°	°	°	°	
1868	......	......	......	41.9	44.6	49.3	54.3	57.4	54.5	50.0	46.6	43.0	....
1869	42.3	41.5	38.8	39.9	43.0	46.2	50.0	52.3	49.6	......	......	......	....
Mean	42.3	41.5	38.8	40.9	43.8	47.8	52.1	54.7	52.0	50.0	46.6	43.0	46.2

HELLISÖ, LATITUDE 60° 45′ N., LONGITUDE 4° 43′ E. OF GREENWICH.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual mean.
1867	......	......	......	......	......	......	......	......	52.2	50.2	46.4	43.5	....
1868	40.6	40.3	40.6	42.1	43.7	52.2	53.4	60.4	56.8	52.7	47.8	45.7	....
1869	43.0	......	......	42.6	45.3	47.3	52.3	54.7	54.0	......	......	......	....
Mean	41.8	40.3	40.6	42.4	44.5	49.8	52.8	57.5	54.3	51.4	47.1	44.6	47.3

UDSIRE, LATITUDE 59° 18′ N., LONGITUDE 4° 52′ E. OF GREENWICH.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual mean.
1867	......	......	......	......	......	......	55.8	59.4	57.6	50.5	46.4	42.4	....
1868	38.5	40.1	39.6	41.4	46.8	53.4	56.7	61.7	57.2	52.0	47.1	44.6	....
1869	41.0	42.1	40.3	42.4	46.2	48.0	53.4	56.8	53.8	......	......	......	....
Mean	39.7	41.1	39.9	41.9	46.5	50.7	55.3	59.3	56.2	51.2	46.7	43.5	47.5

TORUNGEN, LATITUDE 58° 24′ N., LONGITUDE 8° 48′ E. OF GREENWICH.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual mean.
1867	......	......	......	......	......	......	59.0	62.4	58.1	51.4	45.7	38.3	....
1868	32.2	37.2	37.6	39.9	48.4	56.5	64.8	66.0	58.3	52.0	45.7	41.2	....
1869	37.0	39.5	34.9	41.7	48.4	55.0	59.5	60.3	57.2	51.8	......	......	....
Mean	34.6	38.4	36.3	40.8	48.4	55.7	61.1	62.9	57.8	51.8	45.7	39.7	47.7

LISTER, LATITUDE 58° 6′ N., LONGITUDE 6° 34′ E. OF GREENWICH.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual mean.
1867	......	......	......	......	......	......	58.6	61.2	57.2	51.1	46.0	40.1	....
1868	36.3	41.0	41.2	44.6	51.6	54.5	62.8	64.4	56.7	51.4	45.3	41.7	....
1869	38.7	40.6	39.0	43.2	48.4	52.5	57.6	59.4	56.5	......	......	......	....
Mean	37.5	40.8	40.1	43.9	50.0	53.5	59.7	61.7	56.8	51.2	45.6	40.9	48.4

LINDNESNES, LATITUDE 57° 59′ N., LONGITUDE 7° 3′ E. OF GREENWICH.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual mean.
1868	37.2	39.9	39.2	42.4	49.6	52.2	61.0	64.0	58.1	53.6	47.3	43.2	....
1869	39.9	40.1	37.8	42.1	45.7	50.7	55.6	59.4	57.2	......	......	......	....
Mean	38.6	40.0	38.5	42.2	47.6	51.4	58.3	61.7	57.6	53.6	47.3	43.2	48.2

Of equal importance with the observations of the Scottish Meteorological Society are the above by the Norwegian Meteorological Institute at Christiania, which has existed since 1866 under the direction of Professor Mohn, supported by the government.[32] The stations of the institute extend along the entire Norwegian coast, from Torungen and Lindnesnes, in the south, to Fruholmen in the north, (57° 59′ to 71° 5′ 45″ N. latitude.) Professor Mohn kindly sent me the above table.[33]

Since then he has published two memoirs, containing the same results, but only the mean values of the whole series of observations, and not the results of single years.[34] The observations are made once or twice, sometimes thrice a day; the diurnal fluctuation of the temperature of the sea does not exceed a few tenths of a degree.

I copy from the first memoir (p. 7) the following table of the annual means of the temperature of the sea, from the observations of the Norwegian Institute and the Scottish Meteorological Society:

Stations.	Winter.	Spring.	Summer.	Autumn.	Year.	Difference of warmest and coldest month.
	°	°	°	°	°	°
Stykkisholmr	33.8	34.5	48.2	43.3	39.8	19.3
Reikiavik	33.8	37.4	49.3	42.8	40.8	18.9
Thorshavn	42.8	42.4	48.4	46.8	45.1	8.8
Sandwick	46.0	44.8	52.9	52.5	49.1	11.7
Stornoway	44.8	46.6	54.3	51.6	49.3	11.5
Harris	44.8	45.3	54.0	51.4	48.9	12.1
Oban	44.6	44.6	53.1	52.3	48.6	12.6
Sea near Oban	....	....	53.1	....	....	....
Otter-house	44.6	45.7	54.1	51.4	48.9	12.1
West Haven	42.1	46.8	57.2	50.7	48.9	17.3
North Berwick	41.5	44.8	54.1	50.7	47.8	14.6
Dunbar	41.2	44.8	54.7	50.7	47.8	15.8
Fruholmen	37.8	36.1	45.7	43.7	41.2	11.2
Andennes	34.0	38.7	50.7	42.4	41.5	18.7
Villa	35.4	40.6	53.1	45.0	43.5	20.2
Ona	42.3	41.2	51.6	49.6	46.2	15.8
Hellisö	42.3	42.4	53.1	51.4	47.3	17.3
Udsire	41.4	42.8	55.0	51.4	47.8	19.3
Lister	39.7	44.8	58.3	51.4	48.6	24.3
Lindnesnes	40.8	42.8	57.0	52.7	48.4	23.2
Torungen	37.6	41.7	59.9	51.8	47.8	28.3

From the second memoir of Mohn, "Oversigt, &c.,"[35] I take the following table of the means of the observations made hitherto of the temperature of the air:

Position, &c., of the Norwegian meteorological stations.

Stations.	Latitude N.	Longitude E. of Greenwich.	Elevation above the sea.	Number of years.	Stations.	Latitude N.	Longitude E. of Greenwich.	Elevation above the sea.	Number of years.
	° ′	° ′	Feet.			° ′	° ′	Feet.	
Vardö	70 22	31 07	7	2	Bergen	60 24	5 20	8	7
Hammerfest	70 40	23 40	......	6	Ullenswang	60 19	6 39	......	25
Kofjord	69 57	23 02	12	12	Skudesnaes	59 09	5 16	6	7
Tromsö	69 39	18 58	7	1	Mandal	58 02	7 27	9	7
Bodö	67 17	14 24	4	4	Sandösund	59 05	10 27	7	7
Ytteröen	63 49	11 14	17	4	Christiania observatory	59 55	10 43	12	31
Christiansund	63 07	7 45	11	2	Dovre	62 05	9 07	343	4
Aalesund	62 29	6 09	5	2					

Temperature of the air, monthly mean.

Stations.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual mean.
	°	°	°	°	°	°	°	°	°	°	°	°	°
Vardö	18.5	19.8	23.2	28.8	34.9	41.4	47.3	48.2	41.5	34.7	26.1	21.6	32.2
Hammerfest	22.6	22.3	26.1	30.2	37.6	46.0	53.1	50.5	44.8	36.1	31.3	24.3	35.4
Kåfjord	18.3	15.4	20.3	29.7	39.2	47.7	54.3	54.3	44.1	32.0	24.6	21.9	33.6
Tromsö	21.7	20.1	25.0	30.6	38.3	47.7	48.6	49.6	44.1	37.4	35.6	23.5	35.1
Bodö	26.6	26.8	29.3	34.0	41.4	50.0	54.5	54.1	48.6	40.6	32.9	27.5	38.7
Ytteröen	25.0	26.1	28.6	36.0	47.5	53.1	55.8	55.8	51.1	41.5	33.1	27.1	40.1
Christiansund	33.8	32.7	34.2	39.0	45.0	52.5	54.7	55.4	52.3	44.4	38.1	36.1	43.2
Aalesund	35.1	34.2	35.1	39.9	45.0	52.2	54.5	55.4	52.7	45.3	39.2	37.8	43.9
Bergen	32.7	31.8	35.1	40.8	49.1	55.8	58.1	57.4	53.6	45.3	38.1	35.6	44.4
Ullenswang	30.6	32.4	34.2	42.4	52.0	57.6	62.4	60.4	53.6	45.5	36.5	32.5	45.1
Skudesnaes	34.7	34.0	35.4	39.9	47.3	53.8	55.4	57.3	54.0	46.8	40.3	37.6	44.8
Mansal	30.9	30.6	33.8	39.4	48.4	55.8	58.8	58.1	52.9	45.1	37.8	34.2	43.9
Sandösund	28.6	28.0	31.6	39.4	49.3	57.9	61.2	60.6	55.0	45.3	37.0	32.0	43.7
Christiania	22.8	23.0	28.9	38.7	49.7	58.6	61.7	59.4	52.3	41.6	31.6	25.5	41 2
Dovre	14.5	17.4	20.3	30.4	39.6	48.6	52.0	50.5	41.9	32.5	25.0	17.8	32.5

Compared with these valuable and meritorious labors of the Scottish Society and the Norwegian Government, hardly anything has been done in the same field in the other parts of Europe. There are to be found in the various text-books of Professor Dove the following:[36]

Means of observations of the temperature of the water in the Baltic Sea.

Stations.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
	°	°	°	°	°	°	°	°	°	°	°	°
Copenhagen	34.5	33.8	35.6	40.6	50.5	58.6	62.4	64.4	58.3	50.5	43.3	37.8
Doberan	35.1	34.2	35.1	43.0	49.3	57.6	64.4	65.1	60.6	55.2	46.8	38.7
Revel	30.9	31.1	31.6	31.6	42.6	53.1	57.7	61.5	55.4	43.3	38.3	34.3

At Kiel Messrs. Meyer and Möbius have made from June 23, 1863, to June 29, 1864, interesting observations of the temperature of the sea on the surface and in depths of from 5 to 16 fathoms.[37] The monthly means of the surface temperatures are:

Station.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
	°	°	°	°	°	°	°	°	°	°	°	°
Kiel	32.0	32.0	34.9	41.5	45.5	61.0	64.2	62.6	58.3	54.1	46.0	40.6

The observations at Copenhagen extend over five to eight years, those at Doberan over four and one-third years, (twice daily,) and those at Revel, according to Wesselowsky, through the years 1847, 1849, and 1850.

The temperatures for the extreme months, at a few points of the East Atlantic Ocean, as far north as the Shetland Islands, by Dana,[38] are but roughly approximating values, and cannot be taken into account in connection with the numerous precise observations extant for that region.

Mr. Von Freeden, the director of the North German "Seewarte," writes in regard to the sea temperature near the coasts of the German Sea and the Baltic, as follows:

Nothing is known of the temperature of the sea on our northern coasts. Summer temperatures may probably be obtained from the administration of the sea-bath at Norderney; they are, at least, noted there on a black-board during the season at each flood, but I do not know whether the record is preserved. I believe that since new-year, also at the Bremen light-house a record is kept of the temperature of the sea, but I am not sure of it.[39]

It is indeed time that "scientific Germany" should, in regard to meteorological observations, not lag behind Norway, Scotland, and Iceland.

The Danish marine department, since August 1868, has directed that regular observations be made on the five light-vessels stationed in the Kattegat and in the sound; until now they were made in all the months except December, January, and February, but at the request of Dr. E. Löffler, in Copenhagen, observations will hereafter be made also during the three winter months. The temperature of the water and of the air, the direction of the current and the winds are observed five times daily. The following monthly means, obtained from the original records of the marine department, have kindly been communicated to me by Dr. Löffler:[40]

Sea temperature observed at the Danish light-vessels in the Kattegat and in the Sound.

Stations.	Latitude.		Longitude E. of Greenwich.		March.	April.	May.	June.	July.	August.	September.	October.	November.
	°	′	°	′	°	°	°	°	°	°	°	°	°
Trindelen	57	26	11	17	35.6	41.7	48.4	53.8	59.9	61.5	57.0	51.4	43.0
Lasö Rende	57	13	10	42	37.4	43.7	51.1	55.8	61.9	62.6	59.2	53.6	43.2
Kobbergrunden	57	08	11	21	35.1	41.2	48.0	53.1	60.4	62.1	57.0	51.1	41.9
Knoben	56	46	11	51	37.0	43.4	50.9	55.8	......	......	58.3	52.0	......
Drogden	55	33	12	44	35.4	41.7	49.6	54.1	59.2	59.0	56.3	50.9	42.4

Dr. Löffler contemplates making observations in Danish waters in the summer of 1870.

With the Danish observations begin the series of those which do not extend over all the months of the entire year, but only principally over the summer half of the year. In enumerating them, I shall confine myself particularly to those referring to the month of July, the subject of Chart No. 1.

General navigation ceases, on the average, with the 50th degree of northern latitude; only a few ships' courses go beyond it. Toward the 60th degree we find the courses between the Danish Colonies in West Greenland and their mother country, and then again the many courses of the British expeditions of discovery to Baffin's Bay, both of which sources furnish valuable contributions toward the knowledge of the ocean. But between them and Maury's figures remains a wide belt, for which hitherto observations have been wanting; the tables below cover this gap for the first time.

The vessels of the Montreal Ocean Steamship Company sail from the north of Ireland, on the great circle, to the Belle-Isle Straits, and thus traverse a space not reached by other vessels. There are two termini of this steamship line in Europe; both branches of the society have, with great kindness, caused tables to be constructed of the temperature observations from the records of their vessels, which were furnished me.

On board of the ships of the Liverpool–Montreal line the temperature of the sea is observed: from Liverpool to the 40th degree west of Greenwich, that is in about two-thirds of the eastern part of the ocean, once a day, at noon; from 40° N. to the St. Lawrence each hour, or 24 times a day.

Daily means of the temperature of the sea from the observations on board of the vessels of the Montreal Ocean Steamship Company, between Liverpool and Montreal, on 34 trips, from the 15th of May to the 29th of October, 1869.[41]

Steamer.	LIVERPOOL TO MONTREAL.				MONTREAL TO LIVERPOOL.			
	Date.	Latitude.	Longitude W. of Greenwich.	Temperature.	Date.	Latitude.	Longitude W. of Greenwich.	Temperature.
	1869.	° ′	° ′	°	1869.	° ′	° ′	°
Nestorian	July 10	56 1	11 37	55	Aug. 1	49 14	64 13	54
	July 11	56 32	20 9	52	Aug. 2	50 42	58 2	52
	July 12	56 22	27 8	53	Aug. 3	52 40	51 19	43
	July 13	55 52	35 9	51	Aug, 4	54 31	43 40	49
	July 14	55	42 30	49	Aug. 5	55 30	34 53	54
	July 15	53 18	49 43	47	Aug. 6	55 50	25 45	55
	July 16	51 48	55 41	43	Aug. 7	55 47	16 46	56
	July 17	48 57	62 4	54	Aug. 8	55 17	8 25	57
	Aug. 21	55 54	12 56	57	Sept. 13	50 31	58 27	52
	Aug. 22	56 17	21 51	57	Sept. 14	52 42	51 36	43
	Aug. 23	56 2	29 22	55	Sept. 15	54 30	43 52	49
	Aug. 24	55 17	38 38	50	Sept. 16	55 38	37 15	50
	Aug. 25	53 48	47 13	51	Sept. 17	55 31	30 54	50
	Aug. 26	51 52	55 10	47	Sept. 18	55 42	24 53	54
	Aug. 27	49 6	61 36	53	Sept. 19	55 34	16 8	55
					Sept. 20	55 25	7 49	51
Peruvian	July 3	55 55	13 3	59	July 25	49 12	66 38	60
	July 4	55 43	22 14	58	July 26	49 44	59 51	56
	July 5	55 43	32 2	56	July 27	51 33	56 14	45
	July 6	54 47	41 29	47	July 28	52 22	50 38	46
	July 7	53 7	49 56	47	July 29	53 42	43 54	50
	July 8	51	57 48	43	July 30	54 44	35 38	52
	July 9	49 50	64 57	53	July 31	55 36	27 7	54
					Aug. 1	55 18	18 28	54
					Aug. 2	55 27	9 50	55

Daily means of the temperature of the sea, &c.—Continued.

Steamer.	LIVERPOOL TO MONTREAL.						MONTREAL TO LIVERPOOL.					
	Date.	Latitude.		Longitude W. of Greenwich.		Temperature.	Date.	Latitude.		Longitude W. of Greenwich.		Temperature.
	1869.	°	′	°	′	°	1869.	°	′	°	′	°
Peruvian—Continued	Aug. 14	55	46	12	42	55	Sept. 5	49	14	64	28	49
	Aug. 15	55	59	19	48	56	Sept. 6	50	57	57	50	54
	Aug. 16	55	52	26	25	56	Sept. 7	52	16	51	15	48
	Aug. 17	55	49	33	53	53	Sept. 8	53	24	43		53
	Aug. 18	54	54	41		54	Sept. 9	54	41	35	7	52
	Aug. 19	53	35	48	4	50	Sept. 10	55	45	27	8	53
	Aug. 20	51	48	54	49	48	Sept. 11	55	34	18	33	55
	Aug. 21	49	5	61	18	56	Sept. 12	55	24	9	51	54
Moravian	June 19	55	24	12	39	53	July 11	49	16	64	47	56
	June 20	55	12	20	45	56	July 12	50	42	58	18	48
	June 21	55	6	28	57	54	July 13	52	42	51	31	41
	June 22	54	36	37	21	51	July 14	54	13	43	33	51
	June 23	53	36	44	55	49	July 15	55	7	35	59	52
	June 24	52	21	52	44	38	July 16	55	35	27	57	56
	June 25	51	50	55	30	38	July 17	55	28	19	48	57
	June 26	49	1	61	25	48	July 18	55	28	11	32	57
	July 31	55	33	12	43	57	Aug. 22	49	16	64	55	52
	Aug. 1	55	47	19	57	57	Aug. 23	50	33	58	32	55
	Aug. 2	56	2	28	40	56	Aug. 24	52	21	53	4	45
	Aug. 3	55	41	36	58	53	Aug. 25	53	37	46	15	51
	Aug. 4	54	22	45	17	52	Aug. 26	54	38	38	51	52
	Aug. 5	52	33	52	26	47	Aug. 27	55	28	31	52	49
	Aug. 6	50	14	59	3	52	Aug. 28	55	28	26	1	56
	Aug. 7	49	19	66	3	51	Aug. 29	55	49	20	40	57
							Aug. 30	55	30	13	27	58
Hibernian	May 15	55	22	13	1	56	June 6	49	20	65	10	48
	May 16	55	1	20	14	54	June 7	47	23	58	55	41
	May 17	54	4	28	28	51	June 8	46	43	52	49	40
	May 18	52	29	36	6	46	June 9	48	31	48	21	42
	May 19	50	36	43	21	52	June 10	50	28	42	40	53
	May 20	48	9	48	21	35	June 11	52	13	37	1	52
	May 21	46	25	53	16	34	June 12	53	22	30	20	54
	May 22	46	59	58	16	40	June 13	54		22	20	56
	May 23	49	7	64	22	39	June 14	54	49	14		54
	May 24	47	57	69	31	40						
	June 26	56	7	12	9	56	July 18	49	45	65	3	53

Daily means of the temperature of the sea, &c.—Continued.

Steamer.	LIVERPOOL TO MONTREAL.						MONTREAL TO LIVERPOOL.					
	Date.	Latitude.		Longitude W. of Greenwich.		Temperature.	Date.	Latitude.		Longitude W. of Greenwich.		Temperature.
	1869.	°	′	°	′	°	1869.	°	′	°	′	°
Hibernian--Continued.	June 27	56	48	20	26	57	July 19	50	33	58	35	52
	June 28	56	41	29	3	54	July 20	52	24	53	33	44
	June 29	56	10	37		50	July 21	53	24	47	7	51
	June 30	54	41	45	35	47	July 22	54	20	39	56	52
	July 1	52	52	52	49	36	July 23	55		32	12	53
	July 2	51	42	56	10	39	July 24	55	19	24	24	55
	July 3	49	49	63	1	53	July 25	55	29	17	23	57
	July 4	In the St.		Lawrence		52	July 26	55	20	8	58	57
	Aug. 7	55	57	12	7	57	Aug. 29	49	40	65	31	52
	Aug. 8	56	24	19	38	57	Aug. 30	50	23	59	16	53
	Aug. 9	56	25	25	56	56	Aug. 31	51	50	55	30	52
	Aug. 10	56	6	34	10	55	Sept. 1	53	15	49	5	51
	Aug. 11	55	8	41	1	51	Sept. 2	54	42	41	38	52
	Aug. 12	53	56	48	20	49	Sept. 3	55	18	33	19	53
	Aug. 13	51	53	53	34	45	Sept. 4	55	57	25	3	55
	Aug. 14	50		59	35	55	Sept. 5	55	57	17	3	57
	Aug. 15	49	20	65		55	Sept. 6	55	24	9	1	58
Austrian..............	June 12	55	42	12	19	52	July 4	49	19	65	55	49
	June 13	56	3	20	18	53	July 5	50		59	28	49
	June 14	56	8	28		52	July 6	52	6	53	23	40
	June 15	55	42	36	20	51	July 7	53	15	47	18	50
	June 16	54	7	44	5	50	July 8	54	15	39	55	50
	June 17	52	51	49	58	44	July 9	55	7	32		52
	June 18	51	20	56	55	42	July 10	55	47	23	30	52
	June 19	49	2	63		52	July 11	55	54	15	3	54
North American.......	July 11	55	26	7	2	54	Aug. 7	49	34	60	31	57
	July 12	56	4	11	19	54	Aug. 8	51	36	56	24	52
	July 13	56	28	15	49	55	Aug. 9	53	2	51	30	48
	July 14	56	53	20	22	54	Aug. 10	53	55	45	39	51
	July 15	56	52	25	16	56	Aug. 11	55	1	39	49	54
	July 16	56	34	31	27	55	Aug. 12	56	15	33	57	52
	July 17	56	9	36	54	52	Aug. 13	56	41	26	46	56
	July 18	55	22	42	28	48	Aug. 14	56	36	19	28	57
	July 19	54	11	48	55	48	Aug. 15	56	1	11	51	57
	July 20	52	41	54	9	42	Aug. 16	Off Rathl		in Island.		59
	July 21	51	2	57	45	42						

Daily means of the temperature of the sea, &c.—Continued.

Steamer.	LIVERPOOL TO MONTREAL.				MONTREAL TO LIVERPOOL.			
	Date.	Latitude.	Longitude W. of Greenwich.	Temperature.	Date.	Latitude.	Longitude W. of Greenwich.	Temperature.
	1869.	° ′	° ′	°	1869.	° ′	° ′	°
North American—Continued.	July 22	49	61 7	53				
	July 23	49 25	65 50	58				
Prussian	July 17	56 6	12 34	56	Aug. 9	50 40	58 30	52
	July 18	56 38	21 9	57	Aug. 10	52 45	52 12	48
	July 19	56 22	30 33	55	Aug. 11	54 30	44 31	50
	July 20	55 33	39 7	52	Aug. 12	55 51	36 44	53
	July 21	53 55	46 26	47	Aug. 13	56 30	28 5	54
	July 22	52 21	53 31	44	Aug. 14	56 30	18 16	56
	July 23	49 40	60 5	43	Aug. 15	55 37	8 55	57
	Aug. 28	56 15	12 12	58	Sept. 20	49 28	59 26	50
	Aug. 29	56 18	22	56	Sept. 21	51 15	57 3	42
	Aug. 30	56 18	31 19	52	Sept. 22	53 6	51 3	41
	Aug. 31	55 27	41 23	50	Sept. 23	54 14	46 8	48
	Sept. 1	54	48 20	48	Sept. 24	54 50	39 49	51
	Sept. 2	Off Belle	Isle	51	Sept. 25	55 15	31 43	52
	Sept. 3	Off Antic	osti	57	Sept. 26	55 24	24 7	56
					Sept. 27	55 19	17 2	57
					Sept. 28	55 19	9 10	56
Germany	Aug. 8	55 36	8 20	59	Sept. 3	49 18	60 48	54
	Aug. 9	56 7	14 9	58	Sept. 4	51 34	56 27	44
	Aug. 10	56 9	20 30	57	Sept. 5	52 34	50 2	48
	Aug. 11	56 23	27 50	58	Sept. 6	54 14	43 22	53
	Aug. 12	56	33 59	56	Sept. 7	55 42	35 25	52
	Aug. 13	55 2	40	53	Sept. 8	56 9	27 11	57
	Aug. 14	54 1	46 19	52	Sept. 9	55 44	19 22	59
	Aug. 15	52 50	52 36	43	Sept. 10	55 38	11 21	59
	Aug. 16	51 26	56 42	50	Sept. 11	54 20	5 10	56
	Aug. 17	48 56	62 12	57				
	Sept. 26	55 22	6 18	56	Oct. 21	49 44	59 55	44
	Sept. 27	56 4	12 40	56	Oct. 22	52 8	53 57	40
	Sept. 28	56 43	20 52	55	Oct. 23	53 54	47 40	51
	Sept. 29	56 16	28 49	54	Oct. 24	54 14	42 10	51
	Sept. 30	55 26	36 49	50	Oct. 25	55 32	35 42	49
	Oct. 1	54 20	43 40	50	Oct. 26	55 46	28 20	53
	Oct. 2	53 10	50 42	49	Oct. 27	55 48	21 8	54

Daily means of the temperature of the sea, &c.—Continued.

Steamer.	LIVERPOOL TO MONTREAL.						MONTREAL TO LIVERPOOL.					
	Date.	Latitude.		Longitude W. of Greenwich.		Temperature.	Date.	Latitude.		Longitude W. of Greenwich.		Temperature.
	1869.	°	′	°	′	°	1869.	°	′	°	′	°
Germany—Continued	Oct. 3	51	17	57	18	45	Oct. 28	56	6	14	10	56
	Oct. 4	48	50	62	2	50	Oct. 29	55	28	7	4	54
Nova Scotia	July 25	55	30	8	32	56	Aug. 15	49	39	60	10	55
	July 26	55	29	15	42	53	Aug. 16	57	55	54	58	54
	July 27	56	24	22	22	55	Aug. 17	53	38	48	34	47
	July 28	56	39	29	15	52	Aug. 18	54	40	41	46	47
	July 29	56	15	35	34	50	Aug. 19	55	45	34	35	47
	July 30	55	7	42	5	46	Aug. 20	55	54	26	38	52
	July 31	53	45	49	6	48	Aug. 21	55	57	19	21	54
	Aug. 1	52	1	54	33	46	Aug. 22	55	41	11	42	57
	Aug. 2	50	57	57	37	49						
	Aug. 3	49		62	34	57						
	Sept. 6	55	52	13	52	56	Sept. 26	49	15	66	15	60
	Sept. 7	56	10	20	36	54	Sept. 27	50	50	59	45	61
	Sept. 8	56	20	27	21	54	Sept. 28	52	14	54	3	40
	Sept. 9	55	50	34	23	49	Sept. 29	54	28	47	22	50
	Sept. 10	55	10	41	22	48	Sept. 30	55	31	40	16	48
	Sept. 11	53	41	47	54	47	Oct. 1	56	1	33	34	50
	Sept. 12	51	47	54	28	44	Oct. 2	56	4	26	29	53
	Sept. 13	49	24	60	17	47	Oct. 3	55	54	19	18	52
	Sept. 14	49	17	66	14	53	Oct. 4	55	43	12	7	53
							Oct. 5	54	38	5	19	53

The following table[42] contains the observations of the temperature of sea and air made on board of the steamships of the Glasgow-Montreal line, on the average six times daily, at 4 and 8 o'clock in the forenoon, at noon, at 4 and 8 o'clock in the afternoon, and at midnight.

Observations of the temperature of sea and air on board the vessels of the Montreal Ocean Steamship Company, between Glasgow and Montreal, from May 16 to October 25, 1869.

Month and day.	Position at noon.		Temperature of the surface of the sea.							Temperature of the air.						
	Latitude.	Longitude W. of Greenw'h.	Forenoon.			Afternoon.			Daily mean.	Forenoon.			Afternoon.			Daily mean.
			4*h.*	8*h.*	12*h.*	4*h.*	8*h*	12*h.*		4*h.*	8*h.*	12*h.*	4*h.*	8*h.*	12*h.*	
1869.	° ′	° ′	°	°	°	°	°	°	°	°	°	°	°	°	°	°
May 16	47 31	43 20	....	....	....	41	42	42	41.7	....	....	....	50	47	45	47.3
May 17	47 14	48 28	40	42	45	35	36	....	39.6	40	38	44	35	39	38	39.0
May 18	46 25	53 40	36	36	36	35	35	35	35.4	39	39	37	40	39	36	38.3
May 19	46 35	57 6	35	36	36	41	38	36	37.0	36	37	37	45	36	36	37.9
May 20	48 11	61 6	35	36	....	....	....	....	35.4	36	35	....	....	....	....	35.4
Monthly	means ...	....	....	....	....	....	....	....	37.9	....	....	....	....	....	....	39.7
June 2	46 28	55 12	43	38	38	....	....	....	39.6	43	38	38	....	....	....	39.6
June *3	47 40	50 27	39	38	38	39	....	....	38.5	40	41	42	40	....	....	40.8
June 4	49 37	45 17	41	42	41	46	57	55	46.8	37	38	40	45	46	50	42.6
June 30	55 21	39 19	....	....	....	47	51	....	49.1	....	....	....	50	54	....	52.0
Monthly	means ...	....	....	....	....	....	....	....	43.5	....	....	....	....	....	....	43.7
July 1	54 46	45 29	48	48	47	47	49	46	47.5	50	47	49	49	49	46	48.4
July 2	53 22	50 53	48	47	46	39	38	38	42.6	45	46	47	45	40	40	43.9
July 3	52 5	54 34	41	39	41	44	49	40	42.3	45	39	40	45	42	39	41.7
July 19	52 2	53 40	40	37	43	44	43	40	41.2	41	43	44	43	44	40	42.6
July 20	52 45	47 38	47	48	49	50	51	51	49.3	45	46	48	48	47	48	47.1
July 21	53 55	41 58	51	52	52	51	50	51	51.1	48	49	50	51	50	51	49.8
July 2	55 37	8 21	52	54	55	56	55	58	55.0	52	56	56	56	56	60	56.1
July 3	55 26	16 15	58	60	61	68	61	....	61.7	56	58	64	60	62	....	60.4
July 4	55 25	22 10	60	....	....	61	60	61	60.4	60	....	....	64	59	58	60.1
July 5	55 41	29 31	60	60	58	59	58	54	58.1	59	59	58	58	58	54	57.6
July 6	55 3	39 2	59	53	51	52	50	....	52.9	51	53	53	54	53	50	52.3
July 7	53 25	43 52	50	51	50	56	52	50	51.8	50	51	50	56	52	50	51.6
July 8	55 6	49 40	50	48	45	44	44	44	45.7	46	46	43	46	44	44	44.8
July 9	51 46	55 5	44	44	46	48	46	44	45.3	44	44	50	48	42	49	46.2
July 10	49 50	59 50	51	52	56	54	54	54	53.6	50	54	54	55	52	52	52.9
July 11	49 8	64 20	56	53	54	56	57	53	54.7	58	58	61	58	58	57	58.3
July 12	48 48	69 45	52	50	53	52	54	....	52.3	58	55	58	58	58	....	57.4
July 13	Off Quebec	....	62	63	63	....	....	....	62.6	60	60	60	....	....	....	59.9

* Passed iceberg.

Observations of the temperature of sea and air, &c.—Continued.

Month and day.	Position at noon.		Temperature of the surface of the sea.							Temperature of the air.						
	Latitude.	Longitude W. of Greenw'h.	Forenoon.			Afternoon.			Daily mean.	Forenoon.			Afternoon.			Daily mean.
			4*h.*	8*h.*	12*h.*	4*h.*	8*h.*	12*h.*		4*h.*	8*h.*	12*h.*	4*h.*	8*h.*	12*h.*	
1869.	° ′	° ′	°	°	°	°	°	°	°	°	°	°	°	°	°	°
July 23	49 17	66 18	....	....	....	57	57	....	57.0	....	....	....	58	58	....	58.1
July 24	49 18	61 5	58	60	61	62	57	55	59.0	58	58	62	60	54	54	57.6
July 25	51 21	56 58	54	53	50	48	56	46	51.6	54	51	44	52	59	50	51.6
July 26	51 18	57 11	52	50	....	52	46	44	48.9	54	50	....	56	56	50	53.1
July 27	51 20	57 12	50	....	....	48	52	52	50.4	46	....	....	55	54	48	50.7
July 28	52	52 35	48	50	48	46	44	48	47.3	50	48	48	46	48	48	48.0
July 29	52 16	48 4	48	50	53	55	56	58	53.4	48	50	52	53	52	52	51.1
July 30	52 48	42 43	54	54	55	55	56	51	53.4	51	52	55	55	52	50	52.5
July 31	53 30	36 55	54	54	53	53	53	53	53.4	52	52	52	51	50	50	51.1
Monthly	means ...	....	....	....	....	....	....	....	51.8	....	....	....	....	....	....	52.0
Aug. 1	54 18	31 18	54	56	56	56	....	....	55.6	52	54	55	58	....	....	54.7
Aug. 2	54 39	25 18	58	58	58	58	60	58	58.3	54	55	58	60	58	58	57.4
Aug. 3	54 13	18 42	58	58	58	58	60	58	58.3	56	58	60	58	58	58	58.1
Aug. 4	54 38	12 29	58	58	58	60	58	57	58.1	58	60	60	60	58	58	59.0
Aug. 5	55 20	6 28	59	57	60	58	....	....	58.6	58	58	60	58	....	....	58.6
Aug. 6	52 52	49 58	50	50	....	48	46	44	47.5	52	52	53	56	48	60	53.4
Aug. *7	51 51	54 5	46	46	....	46	47	56	48.0	48	49	54	54	52	52	51.6
Aug. 8	50 4	59 50	....	....	....	52	....	....	52.0	....	....	....	53	....	....	52.9
Aug. 23	51 44	53 19	48	46	48	46	45	47	46.6	48	46	48	46	43	46	46.2
Aug. 24	52 14	48	48	50	52	....	....	....	50.0	45	49	52	....	....	....	48.6
Aug. 12	N. of Ireland		58	56	....	59	58	....	57.9	....	....	....	....	....	....	......
Aug. 13	54 48	12 44	59	60	....	60	59	....	59.9	59	60	....	60	60	....	59.7
Aug. 14	54 11	18 15	58	61	60	61	60	....	59.5	59	60	62	61	60	....	60.4
Aug. 15	54 37	23 18	59	60	....	60	59	59	59.8	61	61	....	60	60	60	60.1
Aug. 16	53	28 46	59	59	....	59	58	....	58.8	59	61	....	60	60	....	59.9
Aug. 17	51 58	33 33	59	58	59	59	58	56	57.9	59	59	51	60	59	52	56.5
Aug. 18	50 57	38 22	57	60	....	60	60	60	59.2	55	57	....	56	55	55	55.6
Aug. 20	48 01	49 42	52	53	55	55	....	....	53.6	52	52	52	53	....	....	52.3
Aug. 21	Off St. Johns'		....	....	....	52	....	....	52.0	....	....	....	52	....	....	52.0
Aug. 22	46 26	53 30	52	....	....	54	61	....	55.6	52	....	....	56	58	....	55.4
Aug. 23	47 44	60 15	61	60	....	60	58	56	59.0	58	59	....	60	56	58	58.3
Aug. 24	49 21	65 15	54	54	....	54	52	....	53.6	53	56	....	56	54	....	54.7
Aug. 20	N. of Ireland		60	59	59	59	59	59	59.2	60	61	61	60	59	57	59.7
Aug. 21	56 18	16 26	59	58	57	59	60	59	58.6	57	56	59	59	58	57	57.6
Aug. 22	56 55	23 52	59	59	58	59	58	58	58.6	59	59	60	60	56	57	58.6
Aug. 23	56 48	30 23	56	56	56	55	55	54	55.4	54	55	57	54	52	50	53.6
Aug. 24	55 13	37 59	52	51	51	51	52	....	51.4	50	48	49	47	47	....	48.2

* Passed iceberg.

Observations of the temperature of sea and air, &c.—Continued.

Month and day.	Position at noon.		Temperature of the surface of the sea.							Temperature of the air.						
	Latitude.	Longitude W. of Greenw'h.	Forenoon.			Afternoon.			Daily mean.	Forenoon.			Afternoon.			Daily mean.
			4h.	8h.	12h.	4h.	8h.	12h.		4h.	8h.	12h.	4h.	8h.	12h.	
1869.	° ′	° ′	°	°	°	°	°	°	°	°	°	°	°	°	°	°
Aug. 25	54 43	44 58	50	51	51	50	51	51	50. 7	46	47	53	54	50	48	49. 6
Aug. *26	52 53	51 6	51	51	49	46	49	48	49. 3	50	52	62	48	....	....	52. 9
Aug. 27	51 6	57 9	47	42	47	54	52	52	49. 1	49	48	50	56	53	52	51. 4
Aug. 28	49 4	62 50	52	52	52	56	56	....	53. 6	51	52	54	64	57	....	55. 6
Aug. 29	Off Quebec	....	55	55	56	....	....	....	55. 4	57	57	62	....	....	....	58. 6
Monthly means	...	....	....	....	....	....	....	....	55. 0	....	....	....	....	....	....	55. 2
Sept. 4	49 00	62 18	48	56	....	58	56	54	54. 5	50	56	....	56	54	55	54. 3
Sept. 5	50 50	57 38	51	54	....	49	45	48	49. 3	52	55	....	54	49	48	51. 6
Sept. 6	52 10	52 5	46	....	....	52	50	....	49. 3	49	....	....	48	49	....	48. 6
Sept. 7	53 5	46 20	52	51	....	54	53	54	52. 7	50	50	....	55	54	52	52. 3
Sept. 8	53 43	40 6	52	52	....	54	52	....	52. 5	52	50	....	52	49	....	51. 8
Sept. 9	54 12	33 20	54	54	....	54	53	52	53. 4	52	53	....	57	51	50	52. 7
Sept. 10	54 43	26 47	54	54	....	56	58	....	55. 6	51	52	....	54	56	....	53. 1
Sept. 11	55 12	20 7	56	....	....	58	56	....	56. 7	54	....	....	54	52	....	53. 4
Sept. 12	55 39	13 7	55	57	....	56	56	54	55. 6	52	54	....	53	52	52	52. 7
Sept. 13	55 30	7 20	58	....	....	....	....	....	58. 1	50	....	....	....	....	....	50. 0
Sept. 11	49 18	64 48	51	51	....	50	50	....	50. 5	57	59	....	52	51	....	54. 7
Sept. 12	49 16	60 45	52	51	51	51	50	52	51. 1	47	52	54	52	49	50	50. 7
Sept. 13	51 27	56 29	48	50	49	47	47	48	48. 2	47	54	58	51	47	45	50. 4
Sept. 14	52 56	51 12	47	45	46	51	50	51	48. 2	47	52	50	48	49	49	49. 1
Sept. 15	54 5	44 48	51	49	42	50	50	49	48. 4	50	49	48	50	50	50	49. 6
Sept. 16	55 4	40 25	51	51	51	51	52	52	51. 4	50	51	51	50	50	49	50. 2
Sept. 17	54 54	35 40	49	52	52	52	50	53	51. 4	50	54	52	52	50	50	51. 4
Sept. 18	54 44	30 44	52	54	53	56	55	54	54. 0	48	51	52	52	50	48	50. 2
Sept. 19	55 3	24 16	55	55	55	56	54	57	55. 4	49	52	56	54	52	53	52. 7
Sept. 20	55 33	17 32	56	56	56	57	57	57	56. 5	50	57	58	55	53	58	55. 2
Sept. 21	53 32	10 13	56	56	57	57	57	57	56. 7	52	54	62	58	54	54	55. 6
Sept. 23	55 45	8 52	58	54	56	56	57	57	56. 3	49	52	56	56	57	56	54. 3
Sept. 24	55 54	14 38	56	....	....	56	56	56	56. 1	57	....	....	57	56	56	56. 5
Sept. 25	56 4	20 15	54	54	56	56	....	....	55. 0	54	54	56	56	....	....	55. 0
Sept. 26	56 16	27 8	53	56	55	54	52	52	53. 6	51	50	54	52	49	49	50. 9
Sept. 27	56 6	32 54	....	....	....	52	51	52	51. 6	....	....	....	47	47	46	46. 6
Sept. 28	55 30	37 10	50	50	....	50	50	....	50. 0	46	46	....	50	49	....	47. 7
Sept. 29	54 13	43 30	50	49	....	50	52	52	50. 4	50	50	....	51	51	50	50. 4
Sept. 30	53 10	48 12	52	52	50	50	50	46	50. 0	50	51	47	48	48	53	49. 6
Monthly means	...	....	....	....	....	....	....	....	52. 9	....	....	....	....	....	....	51. 8

* Passed iceberg.

Observations of the temperature of sea and air, &c.—Continued.

Month and day.	Position at noon.		Temperature of the surface of the sea.							Temperature of the air.						
	Latitude.	Longitude W. of Greenw'h.	Forenoon.			Afternoon.			Daily mean.	Forenoon.			Afternoon.			Daily mean.
			4h.	*8h.*	*12h.*	*4h.*	*8h.*	*12h.*		*4h.*	*8h.*	*12h.*	*4h.*	*8h.*	*12h.*	
1869.	° ′	° ′	°	°	°	°	°	°	°	°	°	°	°	°	°	°
Oct. 1	52 14	53 15	44	49	....	41	42	44	43.9	42	47	....	40	40	40	41.9
Oct. 2	50 14	58 51	46	42	43	50	50	50	46.8	40	39	40	49	48	46	43.7
Oct. 3	49 8	64 25	50	50	....	46	....	....	48.6	50	51	....	46	....	....	48.9
Oct. 15	49 19	66 8	....	....	....	46	47	....	46.4	....	....	....	48	50	....	48.9
Oct. 16	49 1	61 44	47	48	50	50	49	50	49.1	49	51	51	50	51	51	50.5
Oct. 17	51 8	57 35	50	50	50	50	48	47	49.1	53	53	54	53	48	47	51.4
Oct. 18	52 25	53 15	44	42	43	42	38	42	41.7	46	44	45	46	44	44	44.8
Oct. 19	53 44	48 51	43[43]	49	50	50	50	51	48.9	44	50	49	50	49	50	48.6
Oct. 20	54 30	43 10	52	51	49	50	51	50	50.5	48	50	49	50	51	50	49.6
Oct. 21	55 13	37 20	50	50	51	51	50	52	50.7	50	50	50	50	50	50	50.0
Oct. 22	55 18	24 32	54	54	....	53	53	51	52.9	53	52	....	52	50	48	50.9
Oct. 24	55 22	18 13	54	54	56	53	53	54	54.0	51	51	54	52	51	52	51.4
Oct. 25	55 26	11 39	54	54	54	54	53	53	53.6	53	52	52	51	50	50	51.4
Monthly	means ...	....	....	....	....	....	....	....	48.9	....	....	....	....	....	....	48.6

The courses of the steamers of the Glasgow-Montreal line only, for the month of July, 1869, are laid down on Chart No. 1, in order to show the belt embraced by them; of the steamers of the other line, only the temperatures are noted, on account of the small scale of the chart and to avoid confusion.

North of the belt traversed by the ships of the Montreal Ocean Steamship Company, there are, first, the numerous courses of English and Danish ships to Baffin's Bay, but they do not cover the month of January, and hardly July, as they generally start from home in April and May and return in September and October.

For our purposes, however, even the single course of the brilliant cruise of Captain Inglefield, who left Woolwich July 4, 1852, in the steam corvette Isabelle, of 149 tons, to assist in the search for Sir John Franklin, is of great value. After having sailed around Scotland, he crossed the North Atlantic, between the parallels of 58° and 61°, from the 12th to the 30th of July, when he arrived at Cape Farewell. He kept an excellent journal, and observed, among other phenomena, the temperature of the surface of the sea, the results of which observations are laid down on Chart No. 1.[44]

The journals of Danish ships going to Greenland and Iceland have been collected, for nearly twenty years past, by Captain (now Rear-Admiral) C. Irminger, who has published, at various times since 1853, in the Danish "Nautical Archives" and in German[45] and English geographical periodicals, his conclusions drawn from these journals in regard to currents. When begging the admiral, August 31, 1869, for the latest results of his researches, he had the goodness to send me the memoir accompanying this, "The Temperature of the North Atlantic Ocean and the Gulf Stream," with the following remarks:

I wished to send you something not generally known, a description of the waters of a higher temperature running in bands through the North Atlantic. To construe the table accompanying my memoir has been quite a task, as I had to examine carefully the various ships' logs and to make many computations; my principal aim was accuracy and sureness.[46]

These bands of a higher temperature are to be found, more or less, where a warm and a cold current converge, as, for instance, east of Iceland; the two principal bands, alluded to by Admiral Irminger, in about 60° N. latitude, between the Shetland Islands and Cape Farewell, are doubtless the two convex vertexes of the Gulf Stream in that region, (compare Chart No. 1.) The fact that the entire sea between Scotland and Iceland consists of a great number of such warm and cold bands is best proved by the cruise of Lord Dufferin, who, sailing from Stornoway, in the Hebrides, to Reikiavik, between the 13th and 20th of June, 1856, observed the temperature of the surface of the sea each two hours, in all ninety times, and found it to change not less than forty-four times, or, in the average, once in 14 nautical miles, the change fluctuating between 52°.9 and 43°; for the most part, however, between 50° and 47°.8, while, on starting from Stornoway, the temperature was observed to be 48°, and on arriving at Iceland again 48°.

From the concluding sentence of Admiral Irminger's memoir, it would appear that he assumes the two warm bands in 60° N. latitude, which I take for the vertex of the Gulf Stream, to be only branches of it, and, consequently, that the mild winter climate of Europe is not solely attributable to the Gulf Stream. I shall speak of this hereafter.

The material collected by Admiral Irminger is not nearly so extensive as that of Maury, Andrau, and others; but is, nevertheless, of very great value for the knowledge of the currents and of the temperature about Iceland and around the southern cape of Greenland. The data, published so far, are three ship's courses to Greenland and twenty to Iceland, between 1844 and 1859, and exclusively in the summer months, April to September.[47] To make a proper use of them, they should be considered for each month separately, and not, as Irminger has done, by throwing together the observations for all the six months. It then will clearly be seen from them that, in the summer months, one arm of the Gulf Stream proceeds not only along the west side of Iceland, but extends also around the north coast eastward up to Langenaës, where the polar stream sets against the coast and proceeds along the entire east and southeast coast, in general in a southwestern direction, between Iceland and the Faroe Islands; while the eastern arm of the Gulf Stream keeps between the latter and Scotland, and thence principally turns to the northeast. Toward the fall, even in August and September, the lateral polar current on the southeast coast of Iceland loses more and more of its preponderance, until the Gulf Stream occupies the entire space between Scotland and Iceland.

Admiral Irminger has sent me, also, interesting notes[48] on "the ice in the summer of 1869," in the region between the Shetland Islands and South Greenland, throughout Davis' Strait and in Baffin's Bay, up to Upernivik, (in 73° N. latitude.) He says:

Captain Bang, during his entire passage from Denmark to Greenland and through Baffin's Bay up to Upernivik, in the summer of 1869, saw no ice at all in the ocean, except a few icebergs in the vicinity of Omenak Fiord, (latitude 71° N.,) from whence such very frequently drift into the open sea.

There was, in general, remarkably little ice in 1869 around Farewell, the southernmost cape of Greenland; the masters of nearly all of the nine vessels of the Royal Greenland Mercantile Society, of which some make two trips annually to Greenland, reported having seen, except in April and May, no ice at all in the ocean up to Greenland. A year so free of ice has not happened for a long time. In 1868, on the contrary, the Greenland coast was encased by very great fields of ice almost all the time, which has not occurred for many years; four merchant vessels were compelled to winter in Greenland, and were detained until March and April 1869.

On the northern and eastern coasts of Iceland, however, there was, in the summer, considerable ice, which did not disappear before August. In my opinion, the ice encasing the north and east coasts of Iceland was but a very small part of the great masses which generally come each year down the east coast of Greenland and pass around Cape Farewell. We may expect to learn, through the German North Polar Expedition, whether much or little ice has broken loose and drifted south, in 1869, from the Arctic.[49]

In 1869 the British government sent a scientific expedition, in her Majesty's ship Bulldog, to the Northern Sea, to examine the line between Scotland, the Faroes, Iceland, Greenland, and Labrador, for the purpose of eventually laying a submarine telegraph; it obtained very valuable results as to depths, animal life in the ocean, &c.; in fact, the labors of Dr. Wallich, the naturalist of the expedition, mark an epoch in the natural history of marine animal life. But few observations of temperature were made—about half a dozen;[50] the expedition, nevertheless, has added to the better knowledge of the Gulf Stream, as will be shown hereafter.

Although only a pleasure trip, yet of eminent value to the knowledge of the entire Northern Sea, from the parallel of the German coast to the latitude of 80° N., is *Lord Dufferin's cruise to Iceland and Spitzbergen* in a sailing yacht of 85 tons in 1856.[51] The principal dates of this cruise are: Sailing from Stornoway, in the Hebrides, June 13; Reikiavik, June 20; the north-western cape of Iceland, July 9; Jan-Mayen, July 13; Hammerfest, July 20; Bear Island, July 31; Spitzbergen, (English Bay,) August 6; Drontheim, August 26; Bergen, August 31; Copenhagen, September 10; Christiansand, September 19; arrival in England, September 25. During these three and a half months Lord Dufferin kept an excellent journal of observations of the temperature of the sea and of the air, and of the weather, for each two hours, day and night, twelve times from noon to noon; their great value lies principally in the direction of the cruise—from Scotland around Iceland to Jan-Mayen, and thence to Hammerfest. To this day there is no other cruise and no other connected series of observations existing on that line. The lowest temperature of the sea, during this trip, was observed 70 nautical miles west of Bear Island, (30°;) the highest (north of the Arctic Circle) between the 18th and 19th of July, in 70½° N. latitude and 15° longitude E. of Greenwich, about 80 nautical miles off the Scandinavian coast, (54°.) Further southward, in the German Sea, from Bergen to Copenhagen and from there to England, between the 3d and the 25th of September, temperatures of from 51°.6 to 68°.4 are noted; generally, however, they were found to be between 54°.5 and 59°.[52]

The observations of Lord Dufferin, in themselves, offer so numerous data that they permit the construction of isothermal curves for the Northern Sea from 50° to 80° latitude, or from the coasts of the German Sea up to Spitzbergen, Iceland, Jan-Mayen, and Bear Island. Among other facts they demonstrate that an arm of the Gulf Stream extends along the entire west and north coast of Iceland, and that the cold Polar Stream penetrates at Bear Island far to the westward.

For the Greenland Sea up to 80° N. observations of the temperature of the sea exist since Scoresby in the beginning of this century; and Parry, in 1827, extended them to $82\frac{3}{4}°$ N. These various data are represented on my chart of 1852, accompanying Sutherland's book. In the construction of the present Chart No. 1, however, I have confined myself to the use of only the later and more complete series of observations which were made in 1868 by Koldewey and Nordenskiöld, and in 1869 by Dorst and Bessels.

Captain Koldewey, in the first German North Polar expedition in 1868, like Lord Dufferin, observed every two hours; his observations extend from May 25 to September 29, and reach from Bergen ($60\frac{1}{2}$ N. latitude) to 81° 04′ N. latitude;[53] but the isothermal lines, constructed from them without regard to other observations, would convey an erroneous impression of the main facts in regard to the currents and the temperature in the Northern Sea, as they place the source of the higher temperature southward near the Scandinavian coast, (as if the Gulf Stream was coming from the German Sea,) instead of southwestward into the Atlantic Ocean. At Spitzbergen, also, not only the isothermal curve of 4° Réaumur, (41° Fahrenheit,) but also that of 2° R. ($36\frac{1}{2}°$ F.) is interrupted by the Polar Stream, which at the South Cape penetrates far to the westward.

Dr. Dorst, in Rosenthal's steamer Bienenkorb, (Bee-hive,) left the Weser February 21, and returned August 31, 1869, during which time, not landing anywhere, he observed for temperature each second hour without any gap. The following is a copy of the observations in the month of July.[54]

Air and sea temperature of the Greenland Sea (latitude 71° 40′ to 74° 40′ N., longitude 8° 50′ to 13° 10′ W. of Greenwich) in July, 1869. Observed by Dr. Dorst in Mr. Rosenthal's steamer Bienenkorb.

Date.	12*h*.		14*h*.		16*h*.		18*h*.		20*h*.		22*h*.		0*h*.		2*h*.		4*h*.		6*h*.		8*h*.		10*h*.		Mean.		Difference of air and sea.
	Air.	Sea.	Air.	Sea.	Air.	Sea.	Air.	Sea.	Air.	Sea.	Air.	Sea.	Air.	Sea.	Air.	Sea.	Air.	Sea.	Air.	Sea.	Air.	Sea.	Air.	Sea.	Air.	Sea.	
1869.	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
July 1	32	31	32	31	32	31	32	32	32	32	32	32	31	32	33	32	32	32	32	31	31	31	31	31	31.8	31.3	+ 0.5
2	29	31	28	31	28	31	28	31	29	32	30	32	32	32	32	32	32	32	34	32	32	34	30	33	30.3	31.8	— 1.5
3	29	31	32	32	33	32	34	32	33	32	34	32	31	32	31	33	33	33	31	33	30	33	28	32	31.6	32.1	— 0.5
4	30	32	30	32	31	32	31	32	31	32	32	31	31	31	31	32	31	33	32	32	32	33	31	33	31.0	31.9	— 0.9
5	33	33	33	33	33	32	33	32	32	33	32	32	32	32	33	32	33	32	33	32	32	33	32	33	32.5	32.2	+ 0.3
6	31	32	30	32	30	32	29	32	29	32	31	32	32	32	32	33	32	33	32	32	32	32	31	31	31.0	32.0	— 1.0
7	31	31	32	31	33	31	34	32	35	32	36	32	35	32	32	32	32	32	31	32	31	33	30	32	32.6	31.7	+ 0.9
8	31	32	32	32	34	32	35	32	37	33	37	33	37	33	37	33	35	33	34	32	33	33	31	32	34.2	32.2	+ 2.0
9	29	31	29	31	29	32	28	32	29	32	33	32	33	32	33	33	32	33	34	33	35	33	34	33	31.4	32.2	— 0.8
10	34	33	33	33	33	33	35	33	33	33	34	33	33	33	33	33	34	33	34	33	33	33	34	33	33.2	33.1	+ 0.1
11	33	33	33	33	33	33	33	33	32	32	32	32	33	32	33	32	33	32	33	32	33	32	33	32	32.5	32.2	+ 0.3
12	32	32	33	32	33	32	33	32	33	32	33	32	33	32	33	32	33	32	33	32	33	31	34	31	32.9	31.8	+ 1.1
13	33	32	32	32	33	32	32	32	34	32	33	32	33	31	33	32	33	32	33	33	34	33	33	33	32.9	32.1	+ 0.8
14	33	32	33	32	33	32	34	33	36	33	36	33	37	34	36	34	36	34	33	34	35	34	35	34	35.1	33.3	+ 1.8
15	35	34	34	34	34	34	34	34	35	34	35	34	35	34	35	34	34	34	34	34	35	34	34	33	34.6	34.0	+ 0.6
16	34	32	33	33	33	34	33	34	34	34	35	34	36	34	35	34	35	34	35	34	36	34	35	34	34.5	33.8	+ 0.7
17	35	35	35	34	35	34	35	34	35	34	35	34	35	34	36	34	35	34	35	33	35	34	34	34	35.1	33.9	+ 1.2
18	34	34	34	34	34	34	34	34	35	34	35	34	36	34	37	34	37	35	37	35	36	36	34	33	35.3	34.2	+ 1.1
19	34	34	34	34	34	34	35	34	34	34	34	34	34	34	34	34	34	34	34	34	34	33	34	33	33.9	33.8	+ 0.1
20	33	33	33	33	32	33	31	33	33	34	34	33	34	33	35	33	34	33	35	34	35	34	34	34	33.7	33.4	+ 0.3
21	34	34	34	34	34	34	33	34	34	34	34	34	34	34	35	34	35	34	35	34	35	34	35	34	34.4	33.9	+ 0.5
22	35	33	35	34	35	34	36	34	36	34	36	34	35	34	35	34	35	34	35	34	33	34	34	35	34.1	34.1	+ 0.8
23	34	35	34	35	33	35	34	34	34	35	33	35	33	35	34	34	34	34	33	35	34	35	34	35	33.6	34.7	— 1.1
24	33	35	33	34	34	34	34	34	33	35	33	34	33	33	33	33	33	32	32	31	32	31	32	31	32.9	33.0	— 0.1
25	32	33	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	33	32	32	32	32.2	32.2	0
26	32	32	32	31	32	32	33	32	33	32	33	32	33	32	34	32	35	32	36	32	34	32	33	32	33.3	31.8	+ 1.5
27	33	32	33	32	33	33	33	33	33	33	33	33	33	33	33	33	32	33	32	33	32	33	31	33	32.6	32.6	0
28	30	33	31	33	31	33	31	33	32	33	32	33	32	33	31	33	32	33	31	33	30	33	31	33	31.1	32.6	— 1.5
29	30	32	31	32	32	32	32	32	33	32	34	32	34	32	34	32	32	33	32	33	32	33	32	32	32.3	32.2	+ 0.1
30	31	33	31	33	31	33	32	33	33	33	34	33	36	33	34	33	34	33	34	33	34	34	31	33	32.9	32.9	0
31	31	33	31	33	32	33	34	32	34	32	34	32	34	33	36	32	35	33	35	33	34	33	34	32	33.6	32.5	+ 1.1
Mean..	32.3	32.5	32.3	32.5	32.4	32.7	32.7	32.7	33.1	32.8	33.6	32.8	33.6	32.8	33.7	32.9	33.5	32.9	33.5	32.9	33.2	33.0	32.5	32.7	33.0	32.7	+ 0.3
Differ'c	— 0.2		— 0.2		— 0.3		0		+ 0.3		+ 0.8		+ 0.8		+ 0.8		+ 0.6		+ 0.6		+ 0.2		— 0.2		+ 0.3		....

The field of Dr. Dorst's observations is, in the main, the same as that of Captain Koldewey. It reaches nearly to 79° north latitude, consequently not so far north, but to the south beyond Jan-Mayen; it also reaches not so far east, but somewhat further to the westward.

The Swedish expedition under Nordenskiöld left Tromsö July 20, 1868, and returned to the same place October 20. Observations, also of the temperature of the sea, were made four times daily. The course is shown on a chart published in a previous number of the "Geographische Mittheilungen."[55] The maximum of the temperature of the sea (43°.47) was observed in the Ice Fiord on the coast of Spitzbergen, August 1, the temperature of the air at the same time being 40°.32.

For the knowledge of the Gulf Stream, the observations are of particular interest between Tromsö and Bear Island, where the principal arm of the Gulf Stream sets toward the east. This arm had, July 20 and 21, a temperature up to 47°.3; three months afterward, October 19, still 46°.6. The width of the stream, with a temperature of 45°.5 and more, was, July 20, about 200 nautical miles; October 19, still 170 miles, and to the vicinity of Bear Island, some 80 miles higher north, the sea retained a temperature of 43°.25. The very valuable observations of Sievert Tobiesen on Bear Island, during the winter of 1865–'66, offer important data for comparison.

Professor Nordenskiöld and Dr. Fritch have had the goodness to send me a complete copy of the journal of the Swedish expeditions,[56] from which the July temperatures were taken for Chart No. 1. An abstract of them, however, need not be added here, as most probably the journal has been published in the meantime with the transactions of the Swedish Academy,[57] to which I refer.

While thus for the sea between Spitzbergen and Iceland an abundance of observations was available, (those of Dufferin, Koldewey, Von Otter, Palander, and Dorst, besides the earlier ones, since 1773, by Irving, Scoresby, Parry, Martins, and others,) there were, until 1869, none at all eastward of the meridian 24° E. of Greenwich. There the first were made by Dr. Bessels, in Mr. Rosenthal's steamer Albert, in the summer of 1869, as far as longitude 59° 40′ E. of Greenwich and latitude 76° 45′ N., near the northwest coast of Nova Zembla.

Although the observations were made in the month of August, I have not hesitated to use them for the Chart No. 1 without correction, since the temperature of the sea in that month generally differs from that in July but a few tenths of a degree. Dr. Bessels observed six times daily, as follows:

Dr. Bessels's observations of the temperature of the sea between Spitzbergen and Nova Zembla, August, 1869.[58]

Date.	Position.		Temp.		Date.	Position.		Temp.		Date.	Position.		Temp.	
	Latitude N.	Long. E. of Greenwich.	Sea.	Air.		Latitude N.	Long. E. of Greenwich.	Sea.	Air.		Latitude N.	Long. E. of Greenwich.	Sea.	Air.
1869.	° ′	° ′	°	°	1869.	° ′	° ′	°	°	1869.	° ′	° ′	°	°
Aug. 1	......	......	....	41	Aug. 8	75 11	28 32	35	46	Aug. 14	76 6	44 26	34	39
			....	35				38	42				34	35
			....	34				41	42				....	35
			31	36				42	43				34	36
			32	34				42	43				34	35
			32	38				42	48				....	39
Aug. 2	76 16	20 2	30	35	Aug. 9	76 05	32	41	46	Aug. 15	75 55	45 19	{ ..	37
			33	36				41	41			Storm	{ ..	34
			33	32				41	41				{ ..	35
			32	31				39	41				35	36
			....	33				39	40				36	38
			32	42				33	38				35	39
Aug. 4	76 2	22 5	34	44	Aug. 10	75 36	34 15	33	42	Aug. 16	75 55	45 25	35	39
			33	42				33	38				35	38
			33	33				35	37				35	38
			33	34				32	37				35	38
			33	37				32	40				34	33
			35	40				34	39				35	38
Aug. 5	75 38	22 48	35	40	Aug. 11	75 26	35 47	37	41	Aug. 17	76 31	48 37	35	35
			33	40				37	38				32	31
			34	36				37	37				32	33
			34	36				38	35				33	32
			35	37				39	35				32	32
			32	38				38	35				31	33
Aug. 6	74 59	22 19	32	38	Aug. 12	75 54	38 18	37	35	Aug. 18	76 13	47 59	33	36
			32	35				37	31				32	32
			32	34				34	30				33	32
			32	35				33	30				33	33
			32	37				33	32				33	33
			31	37				33	38				35	34
Aug. 7	74 29	23 2	32	37	Aug. 13	75 44	41 11	32	39	Aug. 19	75 59	52 28	36	34
			32	36				34	33				34	33
			31	34				32	33				34	34
			39	37				33	33				36	31
			37	39				34	26				36	32
			34	47				33	38				35	33

Dr. Bessel's observations of the temperature of the sea, &c.—Continued.

Date.	Position.		Temp.		Date.	Position.		Temp.		Date.	Position.		Temp.	
	Latitude N.	Long. E. of Greenwich.	Sea.	Air.		Latitude N.	Long. E. of Greenwich.	Sea.	Air.		Latitude N.	Long. E. of Greenwich.	Sea.	Air.
1869.	° ′	° ′	°	°	1869.	° ′	° ′	°	°	1869.	° ′	° ′	°	°
Aug. 20	76 6	57 27	34	42	Aug. 24	73 54.5	51 13	39	35	Aug. 28	73 36	30 5	41	39
			35	33				38	33				40	38
			35	34				37	35				42	38
			35	33				39	39				43	37
			....	37				40	38				....	39
			35	39				....	38				45	41
Aug. 21	76 37	59 4	33	40	Aug 25	74 01	50 9	39	39	Aug. 29	73 36	21 52	44	40
			33	35				39	39				44	40
			33	33				....	39				45	35
			31	35				39	40				46	34
			32	34				39	39				46	34
			33	33				40	40				47	38
Aug. 22	75 46	56 31	32	32	Aug. 26	74 2	46 44	40	38	Aug. 30	71 51	17 51	47	38
			32	31				....	37				47	38
			32	31				39	37				46	37
			33	31				40	37				47	37
			33	32				39	38				47	38
			35	31				40	41				47	39
Aug. 23	74 48	52 46	35	33	Aug. 27	73 36	40 52	42	39	Aug. 31	71 29	17 19	48	40
			34	32				41	37				48	38
			35	33				39	35				48	37
			36	33				41	36				48	37
			35	33				41	37				48	46
			39	35				40	40				48	42

Rosenthal's expedition in the Albert, with Dr. Bessels on board, left Bremerhaven May 23, 1869, and returned September 22.[58]

The numerous observations, from those of Lord Dufferin down to those of Dr. Bessels, attain their full value only by grouping them by months and placing them on charts of a large scale; and each of the various series has generally an especial value in itself—that of Bessels by its extent eastward; that of Von Otter and Palander by its duration late into the autumn; that of Dorst by the length of the period (nearly half a year) from the season coldest in the temperature of the sea to the warmest; that of Dufferin by the great area covered, &c. The observations of Dr. Dorst, which concentrate principally upon a distinctly defined part of the Greenland Sea, four degrees of latitude and thirteen degrees of longitude in extent, are of especial importance also in regard to the question as to the extent and the manner of the destruction and the diminution of the polar ice in such an area from March to August. Three ice barriers, contracting gradually to nine degrees of longitude in the same latitude, were observed by Dr. Dorst, and are carefully shown on his charts.

The only sea temperatures which, to my knowledge, have been observed on the coast of Nova Zembla, are those by Von Baer, of the St. Petersburg Academy's expedition, in Matoschkin Sharr, in the direction from west to east.[59]

August 6, 1837	41°.0	40.1
August 11, 1837	39°.2; 39°.9	
August 12, 1837	39°.2	
August 13, 1837	39°.0	

A good synopsis of the earlier observations of the temperature of the sea, on the surface and at various depths, is that of Dumont d'Urville;[60] on those obtained near Spitzbergen Charles Martins has written an excellent memoir.[61]

Of the latest and not yet completed series of observations in the European seas I have to notice those of the Royal Commission on the Irish Oyster Fisheries, which have been in progress since May, 1869, at Aberdeen, Howth, Arklow, Tramore, and Goodwick. The following have been communicated to me so far:

Observations of the temperature of the sea at points on the coast of Great Britain, in 1869, by the Royal Commission on the Irish Oyster Fisheries.[62]

I.—Aberdeen, Bridge of Don, (Latitude 57° 12′ N., Longitude 2° 7′ W. of Greenwich.)
[Staff Commander John Barnes.]

Date.	Temperature of the water.		Wind.	Temperature of the air.	Date.	Temperature of the water.		Wind.	Temperature of the air.
	At the coast.	At sea.				At the coast.	At sea.		
1869.	°	°		°	1869.	°	°		°
May 12	48	46	S. E.	....	June 1	52	50	S. E.	54
May 13	48	46	S. S. W.	....	June 2	52	50	S. W.	54
May 14	48	46	S. E.	....	June 3	52	50	S. W.	54
May 15	48	46	S. E.	....	June 4	52	50	E.	54
May 17	48	46	E.	....	June 5	52	50	E.	54
May 18	48	46	E.	....	June 7	52	50	E.	54
May 28	48	46	N. E.	....	June 12	52	52	S. W.	54
May 29	48	46	N.	50	June 14	52	51	E.	54
May 31	48	46	N.	....	June 15	53	52	E.	54
Mean	48. 0	46. 0	....	50. 0	June 19	52	52	E.	54

Observations of the temperature of the sea, &c.—Continued.

Date.	Temperature of the water.		Wind.	Temperature of the air.	Date.	Temperature of the water.		Wind.	Temperature of the air.
	At the coast.	At sea.				At the coast.	At sea.		
1869.	°	°		°	1869.	°	°		°
June 21	52	52	N. E.	54	July 12	56	54	S. W.	60
June 22	52	52	N. E.	54	July 13	56	54	W. S. W.	60
June 23	52	52	N. N. E.	54	July 14	56	54	S. W.	60
June 24	54	52	N. E.	54	July 15	56	56	S.	60
June 25	54	52	S.	56	July 16	56	56	E.	60
June 26	56	54	E.	58	July 17	58	56	E.	60
June 28	56	54	E.	58	July 19	58	56	E.	60
June 29	56	54	E.	58	July 20	58	56	S.	60
June 30	56	54	E.	58	July 21	56	56	S.	60
Mean....	53. 1	51. 8	....	55. 0	July 22	56	56	S. E.	58
					July 23	56	56	S. W.	60
July 1	56	54	E.	58	July 24	56	56	S. W.	60
July 2	56	54	E.	58	July 26	56	56	S.	60
July 3	56	54	E.	58	July 27	56	56	N.	58
July 5	56	54	S.	58	July 28	56	56	S. W.	58
July 6	56	54	N. W.	58	July 29	56	56	S.	58
July 7	56	54	S. W.	58	July 30	56	56	S.	58
July 8	56	54	S. W.	58	July 31	56	56	S. W.	58
July 9	56	54	S. W.	58	Mean....	56. 3	55. 2	....	59. 0
July 10	56	54	S. W.	58					

II.—Howth, (Latitude 53° 23′ N., Longitude 6° 6′ W. of Greenwich.)
[William Horn.[63]]

May 10	49	....	N. N. W.	50	May 29	50	....	S. E.	50
May 11	49	....	N. W.	50	May 31	....	50	....	50
May 12	48	....	N. W.	50	Mean....	49. 8	46. 6	....	48. 4
May 13	....	40	E.	50					
May 14	50	....	E.	50					
May 15	....	50	E.	50	June 1	50	....	S. E.	50
May 17	50	....	N. E.	50	June 2	50	....	S. E.	50
May 18	50	....	N.	50	June 3	50	....	W.	50
May 19	50	....	N.	50	June 4	50	....	N. W.	50
May 20	....	40	N. E.	50	June 5	50	....	S. W.	60
May 21	50	....	E.	50	June 7	50	....	S.	60
May 22	50	....	E.	50	June 8	50	....	N.	50
May 24	50	....	E.	50	June 9	50	....	N.	50
May 25	50	....	E. N. E.	50	June 10	....	50	N.	50
May 26	....	50	E. N. E.	40	June 11	50	....	N.	50
May 27	....	50	N. E.	40	June 12	....	50	S. W.	50
May 28	50	....	N.	40	June 14	50	....	S. W.	60

Observations of the temperature of the sea, &c.—Continued.

Date.	Temperature of the water. At the coast.	Temperature of the water. At sea.	Wind.	Temperature of the air.
1869.	°	°		°
June 15	50	....	N.	60
June 16	50	....	....	60
June 17	....	50	S.	60
June 18	50	....	S. W.	60
June 19	....	50	S. W.	60
June 21	....	50	S. W.	60
June 22	....	50	N. E.	60
June 23	50	....	N. E.	60
June 24	50	....	W.	60
June 25	....	50	E.	60
June 26	50	....	....	60
June 28	50	....	N. E.	60
June 29	50	....	N.	60
June 30	50	....	N.	60
Mean....	50. 0	50. 0	....	56. 8
July 1	....	50	N. E.	60
July 2	....	50	E.	60
July 3	....	50	S. E.	60
July 5	....	50	W.	70
July 6	....	50	W.	60
July 7	50	....	W.	60

Date.	Temperature of the water. At the coast.	Temperature of the water. At sea.	Wind.	Temperature of the air.
1869.	°	°		°
July 8	50	....	S.	60
July 9	50	....	W.	70
July 10	50	....	S. W.	70
July 12	50	....	E.	70
July 13	50	....	N. W.	60
July 14	....	50	W.	70
July 15	....	50	W.	70
July 16	....	50	S. E.	70
July 17	....	50	S. E.	70
July 19	....	60	E.	70
July 20	....	50	S.	70
July 21	60	....	S. W.	60
July 22	....	60	S. W.	70
July 23	....	60	S. W.	70
July 24	60	....	S. E.	70
July 26	60	....	N. W.	70
July 27	60	....	W.	60
July 28	60	....	W.	70
July 29	50	....	S. W.	60
July 30	50	....	W.	60
July 31	....	50	W.	70
Mean....	53. 8	52. 0	....	66. 0

III.—ARKLOW, (LATITUDE 52° 48′ N., LONGITUDE 6° 12′ W. OF GREENWICH.)
[BOATSWAIN ROBERT MCCONNELL.[64]]

Date.	At the coast.	At sea.	Wind.	Temperature of the air.
June 1	52	50	W. S. W.	60
June 2	56	50	S. W.	58
June 3	52	50	S. W.	59
June 4	50	51	S. W.	54
June 5	50	50	W.	56
June 7	51	52	S. S. W.	74
June 8	52	50	N. E.	58
June 9	54	52	S. E.	60
June 11	50	51	S.	64
June 14	52	50	W.	70
June 16	50	52	S.	60
June 17	50	50	S. W.	58
June 18	52	50	S. W.	56
June 19	50	52	N. E.	54
June 21	50	52	S. E.	72
June 22	50	52	N. E.	64
June 23	50	52	S.	76
Mean....	51. 4	50. 9	....	61. 9
July 3	54	58	S.	72
July 5	54	58	S. S. W.	68
July 10	50	60	S. W.	70
July 12	50	58	N. W.	66
July 13	52	60	N. W.	70
July 14	54	58	W. N. W.	84
July 15	54	58	S. W.	84
July 16	56	60	S.	86
July 17	54	58	S. W.	82
July 20	56	60	S.	76
July 21	54	58	S.	76

Observations of the temperature of the sea, &c.—Continued.

Date.	Temperature of the water. At the coast.	Temperature of the water. At sea.	Wind.	Temperature of the air.	Date.	Temperature of the water. At the coast.	Temperature of the water. At sea.	Wind.	Temperature of the air.
1869.	°	°		°	1869.	°	°	1869.	°
July 22	52	60	S. W.	72	July 30	50	60	S. W.	64
July 23	52	60	S. W.	70	July 31	52	60	S. W.	68
July 24	52	60	S.	72					
July 26	52	60	N. W.	72	Mean....	52. 8	59. 2	....	73. 4
July 28	52	60	S. W.	68					

IV.—Tramore, (Latitude 52° 10′ N., Longitude 7° 12′ W. of Greenwich.)

[Boatswain Richard Johns.]

Date.	Temperature of water.	Wind.	Temperature of air.
1869.	°		°
May 10	52	N. E.	50
May 11	54	S.	58
May 12	54	S.	58
May 17	55	S. E.	63
May 18	55	S. E.	65
May 19	54	N.	66
May 20	54	N.	65
May 21	54	N.	66
May 22	54	N.	66
May 24	56	S. S. W.	60
May 25	57	S. S. E.	67
May 26	55	E.	57
May 27	56	E.	58
May 28	58	N. E.	60
May 29	56	N. E.	60
May 31	57	N.	62
Mean.	54. 7	....	61. 2
June 1	57	W.	65
June 2	57	S. W.	67
June 3	56	W.	65
June 4	56	W.	65
June 5	57	W. S. W.	67
June 7	57	W.	68
June 8	58	W.	69

Date.	Temperature of water.	Wind.	Temperature of air.
1869.	°		°
June 9	61	S. W.	72
June 10	62	N.	74
June 11	61	N.	72
June 12	59	W.	70
June 14	59	N. W.	68
June 15	59	N. W.	68
June 16	60	N. W.	69
June 17	57	W.	65
June 18	57	W.	65
June 19	57	N. W.	65
June 21	59	N.	68
June 22	59	N.	69
June 23	58	N.	68
June 24	65	N.	74
June 25	64	N.	72
June 26	63	W.	70
June 28	64	E.	72
June 29	63	E.	72
June 30	63	E.	73
Mean.	59. 4	....	68. 9
July 1	63	N.	73
July 2	64	N.	74
July 3	65	W.	76
July 5	63	S. W.	68

Date.	Temperature of water.	Wind.	Temperature of air.
1869.	°		°
July 6	63	W.	69
July 7	63	S. W.	68
July 8	65	S. W.	68
July 9	65	W. S. W.	68
July 10	66	W.	68
July 12	66	N.	73
July 13	66	N. W.	73
July 14	64	N. W.	75
July 15	62	N. W.	74
July 16	64	E.	72
July 17	66	W.	74
July 19	66	S. W.	75
July 20	65	S. E.	74
July 21	64	W. S. W.	73
July 22	65	W.	73
July 23	64	W. N. W.	73
July 24	64	W. S. W.	72
July 26	64	W. N. W.	69
July 27	64	N. W.	69
July 28	64	W. N. W.	69
July 29	63	W. S. W.	67
July 30	63	W. N. W.	66
July 31	63	W. N. W.	66
Mean.	64. 2	....	71. 1

V.—Goodwick, (Latitude 52° N., Longitude 5° 2′ W. of Greenwich.)

[Lieutenant J. G. Annal.[65]]

Date.	Temperature of water.	Wind.	Temperature of air.
1869.	°		°
May 10	50	E.	56
May 11	53	N. N. E.	58
May 12	51	N. E.	59
May 13	54	N. E.	63
May 14	52	E.	57
May 15	52	E. S. E.	63
May 17	53	W. S. W.	56
May 18	52	W. S. W.	57
May 19	49	N.	47
May 20	54	N. W.	59
May 21	54	N.	60
May 22	55	N.	63
May 24	53	S.	55
May 25	55	S. E.	61
May 26	55	E.	56
May 27	52	E.	53
May 28	51	E.	50
May 29	51	N. E.	50
May 31	53	N. W.	59
Mean.	52. 6	....	57. 0
June 1	55	S. W.	64
June 2	54	S. S. W.	56
June 3	55	W.	64
June 4	57	W.	63
June 5	60	W.	64

Date.	Temperature of water.	Wind.	Temperature of air.
1869.	°		°
June 7	59	W.	66
June 8	55	N. E.	64
June 9	57	N. E.	64
June 10	58	N. E.	65
June 11	57	N. E.	55
June 12	57	W.	63
June 14	55	N.	62
June 15	55	N. W.	62
June 16	57	N.	62
June 17	57	W.	64
June 18	56	N. E.	56
June 19	55	N. E.	57
June 21	59	N. E.	66
June 22	55	N. E.	64
June 23	56	N.	65
June 24	58	E.	70
June 25	60	Calm.	64
June 26	62	E.	65
June 28	59	E.	70
June 29	59	E.	67
June 30	59	E.	70
Mean.	57. 2	....	63. 5
July 1	62	E.	71
July 2	60	N.	72
July 3	62	E.	69

Date.	Temperature of water.	Wind.	Temperature of air.
1869.	°		°
July 5	60	S. W.	64
July 6	62	W.	68
July 7	60	W. S. W.	64
July 8	60	W.	63
July 9	62	W.	64
July 10	61	N. N. W.	73
July 12	61	N. E.	73
July 13	59	N.	69
July 14	62	N. E.	70
July 15	63	E.	73
July 16	62	E.	70
July 17	63	E.	68
July 19	61	Calm.	64
July 20	63	S.	70
July 21	63	S. W.	70
July 22	60	W.	66
July 23	63	W.	72
July 24	63	W.	73
July 26	62	N. W.	68
July 27	62	E. N. E.	70
July 28	60	S. W.	64
July 29	60	S. W.	63
July 30	62	W.	68
July 31	62	W.	66
Mean.	61. 5	....	68. 4

RECAPITULATION OF THE MONTHLY MEANS.

Months.	Aberdeen, Bridge of Don.			Howth.			Arklow.			Tramore.		Goodwick.	
	Coast.	Sea.	Air.	Coast.	Sea.	Air.	Coast.	Sea.	Air.	Water.	Air.	Water.	Air.
1869.	°	°	°	°	°	°	°	°	°	°	°	°	°
May	48. 0	46. 0	50. 0	49. 8	46. 6	48. 4	......	......	......	54. 7	61. 2	52. 5	57. 0
June..........	53. 1	51. 8	55. 0	50. 0	50. 0	56. 8	51. 4	50. 9	61. 9	59. 4	68. 9	57. 2	63. 5
July	56. 3	55. 2	59. 0	53. 8	52. 0	66. 0	52. 7	59. 2	73. 4	64. 2	71. 1	61. 5	68. 4

In the German Sea there are observations of Dutch herring fishers from 1858 to 1863,[66] which are of interest; but only the mean values are given, which could not be made use of for the two charts.

In the Mediterranean Sea Captain T. Spratt has made valuable observations of the temperature of the sea at various depths, up to 1,240 fathoms.[67] The following are those at the surface of the sea:

Locality.	Date.	Temperature.
		°
In the Syrtis	February 21, 1861	61
In the Syrtis	February 27, 1861	60
West of Alexandria	April 6, 1861	62
On the coast of Egypt	April 1861	63
Between Malta and Tripoli	May 1861	62
Near Crete	June 14, 1860	73
Grecian Archipelago	July 15, 1860	78
Opposite the east end of Rhodes	August 25, 1860	82
Near Crete	September 20, 1862	75
On the coast of Egypt	November 15, 1861	73

The data for the temperature of the air, which were made use of in constructing the two charts, are from various authorities, partly mentioned above; for instance, Buchan, Mohn, Tobiesen, &c. The most voluminous tables are found in Dove's works;[68] the most accurate and most complete synopsis for the entire Russian empire is by A. Wojeikow, published 1869.[69] Of the various more isolated data I mention those kindly communicated to me in manuscript, on different occasions, by Dr. J. Hann, of Vienna, coeditor of the excellent periodical published by the Austrian Society of Meteorology; as, for instance, the monthly means of Swedish observations computed by him, of which he remarks as follows: "The Meteorologiske Iaktagelser i Sverige, prepared by Edlund, give means for five days of twenty-five stations since 1859. There are now eight volumes, the last being that for 1866; unfortunately, no monthly means are given. For the northernmost stations I have computed the following means for the extreme months, embracing a period of five years. They cannot yet be considered normal values, but represent the differences of the stations pretty accurately:

Haparanda - - 65° 50′ N., 24° 11′ E. of Greenwich; January, 11°.7; July, 58°.3
Pitea - - - - 65° 19′ N., 21° 30′ E. of Greenwich; January, 13°.5; July, 58°.8
Jockmock[70] - - 66° 36′ N., 19° 50′ E. of Greenwich; January, 4°.8; July, 56°.5[71]"

3.—THE GULF STREAM, FROM THE OBSERVATIONS UP TO 1870.

The remarks which now follow are intended to explain the two charts accompanying this memoir, the sources of which were enumerated in the preceding pages.

To represent the Gulf Stream in its entirety, at least in some degree, twelve charts would be required, one for each month, and these should be on a far larger scale, and consequently of a far greater size, if they were to contain all the data on which they should be based. These two charts, therefore, are to be considered only a preliminary expedient. If Maury had grouped the thermal observations collected by him by months, and represented them thus on charts, the meteorology of the ocean would have been promoted far more; ninety-six large sheets, however, would then have been required instead of eight.

In order to show the Gulf Stream on two sheets, I have selected the warmest and the coldest months of the year, July and January. It is true, there is generally a delay in the extreme mean temperatures of the sea, by one or two months for the North Atlantic, the highest temperatures falling in August and the lowest in February or March; but, since the charts are intended also to represent the isothermal lines of the air in the parts of the continents influenced by the ocean, and because it was my aim to show the most potent source of heat in summer and that of cold in winter, (in both cases it being extended area of land,) and, at the same time, for comparison, the influences of the sea standing be tween the two extremes, I have retained the months of July and January.

On the Equator, in the Atlantic Ocean, the mean temperature of the surface of the sea is, according to Kämtz, 78°.6;[72] the average maximum in latitude 6° N. is 81°.3;[73] the highest observed temperature in 3° 01′ N., according to Kotzebue, 84°.6; and the mean temperature of the sea between the parallels of 3° N. and 3° S., according to Humboldt, from 80°.1 to 82°.4.[74]

The mean temperature of the air in the equatorial belt of the Atlantic Ocean between 10° N. and 10° S., according to Lenz, is 78°.8.[75]

On the July chart the core of the Gulf Stream shows the form of a tongue of a temperature of 81°.5, (at some places even 84° was observed,) extending north of the Equator to the 38th degree of latitude. This may be called not only a warm, but better, a hot stream. This hot stream produces itself as a double tongue, with a mean temperature of from 77° to

81°.5, (20° to 22° R.,) toward the north as far as the 40th degree of latitude, and toward the east to the 43d degree of longitude W. of Greenwich; that is, far beyond Newfoundland. In January (Chart No. 2) the tongue of 77° (20° R.) reaches to latitude 37° N. and longitude 70° 30′ W.; and at the place where the east end of this tongue of 77° terminates in July, we find in January a temperature of 63°.5 and 65°.8, (14° and 15° R.)

Up to the meridian of the eastern end of Newfoundland the Gulf Stream proceeds first in an east-northeast and then in an east direction, parallel to the American coast, with an average temperature in July of 77° to 83°.8, (20 to 23° R.,) and in January of 68° to 77°, (16° to 20° R.) The highest temperature of the air in Africa in the same parallel in January is only 59°.

From all this it is evident that a mere drift is out of question, as the temperature decreases south of the hot tongues just described; the hot water, therefore, comes exclusively from the direction of the Florida Straits, and not from any other part of the Atlantic Ocean.

Up to Newfoundland the Gulf Stream rebounds toward the north against the coast line, as if against a wall, and runs there along the cold arctic current which follows the opposite direction. The decrease of the temperature in this short distance, from the Gulf Stream to the coasts of Nova Scotia and Newfoundland, is, therefore, very great, in summer as well as in winter—in July about 27 degrees in 340 miles, and in January as much as 45 degrees in the same distance.

At Newfoundland the Gulf Stream comes in violent collision with the Polar Stream of Labrador, which, nearly at a right angle, sets against and penetrates into it like an immense wedge. But the former is now by no means annihilated, as Mr. Findlay concludes; on the contrary, it sallies forth intact from this conflict. There are drifting down, however, each spring, from February to July, but mostly in April and May, from the north, in the southeastern direction of this wedge, which is sharpest defined in July, gigantic icebergs and vast masses of polar ice, which have been observed as far south as 36° 10′ N., (on the same parallel as Gibraltar and Malta,*) principally on the meridian 50° W. of Greenwich; that is, directly in the core of the Gulf Stream, in the hot waters of which these great masses of ice, so to speak, explode when arriving, and disappear in a very short time. The Gulf Stream is not dis-

* The mouth of the Chesapeake Bay on the American side.—Hydrographic Office.

turbed to any degree, either in its direction or in its temperature, until a very short distance east of Newfoundland when it bends sharply toward the north. The influence of the Polar Stream on the isothermal curves of the ocean is still less in January than in July.

The Polar Stream carries down, as a gift of the spring, walruses and polar bears to the coasts of Newfoundland, at a time when on the same parallels of latitude at Mayence, Paris, Cherbourg, or Brest,[76] the plants awake to new life, and nightingales warble their songs. About this time the sea isothermal curve of 45°.5, (6° R.,) as shown on the July chart, penetrates southward beyond the 50th degree of latitude, while 380 miles to the eastward the Gulf Stream, rolling its waters to the north, has still a temperature of 68°. With two convex bends and a width of about thirty degrees of longitude, the latter thence proceeds northward toward Iceland and into the Arctic Sea. In January the isothermal line of 45°.5 (6° R.) reaches from Newfoundland southwardly down to the 42d degree of latitude, and follows the east coast of the United States still further southward to the 37th degree, to about Chesapeake Bay. The two vertexes of the Gulf Stream, as it sets toward the north, are less defined than in July; already on the 50th degree of latitude but one principal bend is perceptible in the isothermal line of 54°.5, (10° R.) In about that latitude an arm of the Gulf Stream sets northwest into Baffin's Bay, along the west coast of Greenland and up to Smith's Sound, as demonstrated by me on another occasion, to which I refer.[77]

While the Gulf Stream has in January, on the 50th parallel of latitude, still a temperature of 54°.5, the thermometer shows at the same time, at Prague or at Ratibor, (in Silesia,) on the same parallel of latitude, temperatures of —24°, and sometimes still lower ones. The isothermal line of 54°.5 (10° R.) runs up in July toward Iceland and the Faroe Islands to the 61st degree of latitude. There it meets for the second time the Polar Stream, which on the east coast of Iceland again threatens to block up its way and to destroy it.

The summer observations of temperature collected by Admiral Irminger, as already noticed, not only show that an arm of the Gulf Stream proceeds toward the north along the west coast of Iceland, but also that this arm extends to the east along the entire north coast, and does not meet the Polar Stream until it has reached the northeast end of the island. Only for the months of May, June, July, and August figures are found in Irminger's collection off the north coast of Iceland, all of which show a higher temperature than those off the east coast. In July temperatures were observed on the north coast of 45°.0; 47°.1, and 49°.3, (Dufferin 46°.0,) while off the east coast, for six degrees of longitude, none higher than from 40° to 42°.6 were found. According to Irminger's data and Lord Dufferin's observations, the Gulf Stream setting toward the north preponderates in July on the west and north coasts of Iceland, but on the east and south coasts the Polar Stream coming from the direction of Jan-Mayen.

Between Iceland and the Faroe Islands the Gulf and Polar Streams are contending against each other, and the result of this struggle is a sea divided in a great number of hot and cold bands, which fact is demonstrated clearly by Lord Dufferin's cruise from Stornoway to Reikiavik, in 1856, and fully corroborated by Wallich in the Bulldog expedition of 1860. The chart accompanying Wallich's memoir[78] has a very good representation of these currents.

The fact that the two streams, in their contest, appear as many bands and strata, alongside, over, and beneath each other, is proved not only by the observations of the temperature of the surface of the sea by Irminger and Dufferin, but also by the researches of Wallich in regard to the nature of the bottom of the sea. The latter found there volcanic stones pointing as to their origin to Jan-Mayen, and at other places ophiocomæ of two to five inches in length, which could have been carried there only by the warm Gulf Stream.[79] Another argument is that the drift ice penetrates here further to the south than anywhere else east of Iceland. Scoresby, for instance, in 1822, observed great masses of heavy ice in latitude 64° 30′ N., longitude 7° 00′ W. of Greenwich, and detached pieces even as far south as 63° 40′ N., (longitude 8° W. of Greenwich,) and as far east as longitude 3° W. of Greenwich, (in latitude 66° 49′ N.[80]) Even still farther southward ice has been seen by Sir James Clark Ross, in latitude 61° 00′ N., longitude 6° 00′ W. of Greenwich, which is southeast of the Faroe Islands.

In the same manner the temperature of the sea at the Faroe Islands, even down to the Shetland and Orkney Islands, appears depressed in comparison with that of the west coast of Iceland. The isothermal lines show, from Jan-Mayen, a remarkable concavity as far as the German Sea, which can be caused only by the cooling influence of the Polar Stream. Reikiavik and Stykkisholmr (latitude 65° 04′ N.) have in July a temperature of the sea of 52°.9 and 50°, while at Thorshavn, in 62° 02′ N., it is only 48°.9. At times the temperature of the air also is, in consequence of this cooling influence, depressed in the entire region from the Shetland Islands to the German coast, as, for instance, in July, 1867, when, on the Shetland Islands, in Scotland, and down to Southern England, it was, on the average, fully 4°.5 lower than the normal temperature.[81]

But here, also, the Gulf Stream comes away equally intact from its struggle with the Polar Stream, as at Newfoundland. We now know its further course in the summer from many direct observations, as far north as Spitzbergen and Nova Zembla, and beyond the 80th degree of latitude. For the winter we still possess but few observations on the high sea, but we know its influences as well as in the summer, partly through the meteorological stations, and, again, from various climatic phenomena on the coasts washed by it.

The mild winter of the British Isles is well known. The mean temperature for January at London is 37°.4; at Edinburgh the same; at Dublin 40°.5. The further we go from east to west or from south to north, or, in other words, the nearer to the Gulf Stream, the higher we find the temperature. At Unst, on one of the Shetland Islands, 560 miles north of London, the mean temperature of the air for January is 40°.3, and that of the sea even 45°.5, (East Yell.)

A drift current, therefore, is out of the question, else the temperature of the air would be higher than that of the sea. Clearly, the warm current of the sea is tempering the air, and not *vice versa.* The lowest temperature observed in London is only —5°; at Penzance, on the west coast, +24°.1; at Sandwick, on the Orkney Islands, +15°.8, and at Bressay, on the Shetlands, +14°.9. At Madrid, +13°.3 has been observed, and 27°.5 even at Algiers, which provides Europe with the cauliflower in winter.*

On the morning of February 8, 1870, the telegraph announced the temperature at Ratibor (in Silesia) to be —25°.4, while northwest of it, at Breslau, it was —13°; at Berlin, —0°.4; at Kiel, +10°.6; and at Christiansand, on the south of Norway, eight degrees of latitude north of Ratibor, +30°.7. So high a temperature would be impossible in Norway, and the winds could not carry it there if they did not derive it from the high-tempered Gulf Stream to the westward.

* At New York and Washington the lowest observed temperature is —4° C. See "Results of meterological observations from 1854 to 1859, compiled by the Smithsonian Institution."—HYDROGRAPHIC OFFICE.

The conclusions of the great mass are apt to be superficial and thoughtless; because, as the Iceland summer is rough and cold, "how very cold must it be there in winter!" But exactly the contrary is the fact. "I must confess," so Dr. Henderson narrates, "that I really shuddered when thinking of living through a winter in Iceland; how greatly was I astonished when I found the temperature not only higher than in Denmark, where I had been during the preceding winter, but also, that the winter in Iceland was by no means more severe than the mildest winter which I had ever known in Denmark and Sweden."[82] Sheep and horses have to take care of themselves during the entire year in Iceland; only cattle and the more valuable saddle-horses are fed in the stable during the winter.[83] How impossible would it be in Germany to leave any domestic animal in midwinter without shelter, even for a few days only! The lakes near Reikiavik are frozen in many winters not more than two inches thick, very rarely to eighteen inches.[84] The lowest temperature of the air experienced in Reikiavik during thirteen years was only +3.9.[85]

It is not to be wondered at that such is the case, because the warm Gulf Stream provides Iceland with heat. Its mean temperature there is, even in January, 34°.7 above zero, and the *lowest temperature noted during twenty years was only* 28°.6. (Compare the table, page 13)

The vertex of the Gulf Stream passes, according to the observations obtained thus far, close to the Shetland Islands; there have been, unfortunately, at that point no observations taken of the temperature of the sea in July; in January the sea retains still 45°.5, while the temperature at the neighboring Faroe Islands in July is 49°; consequently there is, between the warmest and the coldest month, only a difference of 3°.5. This very small oscillation in the temperature of the core of the Gulf Stream is one of its most remarkable qualities. The Faroe Islands are on the same parallel with Hudson Bay, Kamtchatka, and Irkutsk; a drift, "depending solely on the winds," would never be able to cause such relations of temperature. The temperature of the sea at the Scottish stations also demonstrates that the Gulf Stream has in winter relatively a greater preponderance over the Polar Stream than in summer.

Iceland is situated close to the arctic circle and in the latitude of Siberia; we shall now direct our researches within the same latitudes farther eastward to Norway, and closer to the vicinity of the severe climate of Asia.

While on the western side of the North Atlantic Ocean the polar ice reaches down to latitude 36° N., (the parallel of Gibraltar and Malta,) and the name Labrador is sufficient to characterize the climatic qualities of all the land between 50° and 60° N., there extends on the east side of the ocean, along the Norwegian coast, cultivated land up to 71° N., the northernmost land of the world in which, under the influence of the Gulf Stream, agriculture is the main occupation of the inhabitants. Wheat is grown up to Inderoën, in latitude 64° N.; barley up to Alten, in 70° N., where sowing generally is done between the 20th and 25th of June, yielding in the short space of eight weeks, to the 20th or 30th of August, in the average six or seven fold; the potato yields, at the same place, on the average seven or eight fold—in favorable seasons even twelve to fifteen fold; it thrives on the coast as far east as Vadsö, on the Russian boundary line. At Alten (70 N) relishable cauliflower is raised even in less favorable summers.[86] Where washed by the Polar Current, there are, as shown especially by the various Franklin expeditions, under 70° N., but desolate ice deserts without any cultivation, and the place of the destruction of Franklin's own expedition has been located between the 67th and 70th degrees of latitude. On this side there are but the poor snow huts of the Esquimaux; on the other (in 70¾ N.) is the flourishing and busy little town of Hammerfest, where only once the temperature has been as low as +5°, and generally is not less than 9°.5.[87]

While, as in the last winter, Germany has to suffer the frigid air of —24°, and sometimes more intense cold, at that same time Norway gathers a rich harvest under the arctic circle, not from its acres, but in the warm waters of the Gulf Stream, as, for instance, at Aasvaër, in the direction of the vertex of the Gulf Stream, (Chart No. 2;) there the herring makes its appearance about the 10th of December, remaining until the first days of January, and then 10,000 people congregate and haul about 200,000 tons, of a value of more than a million dollars.[88]

From the important deep-sea soundings obtained by vessels of the United States Navy, Professor Agassiz concludes that the waters of the Gulf of Mexico are carried through the Gulf Stream to the coasts of Norway; he considers the *Lophohelia affinis*, (Pourt.,) found in the Gulf of Mexico, identical with the species which is found at the northernmost coasts of Norway, and believes that by the Gulf Stream it is carried from the Tropic sea into those high latitudes.[89]

Up to Hammerfest, however, these wonderful relations might perhaps be caused by the winds of Messrs. Findlay, Blunt, and their adherents, if these only would be kind enough to blow during the entire winter directly from the Gulf of Mexico in one and the same direction over a distance equal to eighty or ninety degrees of latitude, which in reality is not the case; but there the Norwegian coast turns sharply toward the east, and is surrounded henceforth exclusively by the polar ice region and the corresponding icy winds.

A Russian shipmaster, Kononoff, who sailed in 1864 from Cronstadt by the way of Copenhagen, along the Norwegian coast around the North Cape to Kola, arriving there December 17, in fact found no warm winds at all; the temperature of the air, on the contrary, fell to —18°, but the sea retained, up to Kola, so mild a temperature that no ice could form; so that he could reach the open bay of Kola without impediment.[90]

Tschubinski (in "Sapiski dljä Stenia, 1867") states that the winter on the Murmanian coast (Northern Lapland) is not so cold as in the department of Archangel, south of it; that the temperature between latitude 68° and 70° N. rarely falls to —13°, most frequently not below +10° to —2° and that the entire Murmanian coast (the sea up to the Holy Cape, or Svatoi Noss) never freezes.[91] On the contrary, the Baltic Sea, far to the southward, and even the Azov Sea, situated further to the south by twenty-three degrees of latitude, are covered each winter with thick ice.[92] But the Gulf Stream, in the latitude of the Azov Sea, possesses in January a temperature of from +55 to 57°, day and night.

East of the North Cape, distant from it about one hundred and twenty nautical miles, at Vardöe, the temperature of January is +18°.5; while at Petersburg, six hundred and twenty miles south of the former, it is +15°.1. But the most important fact, testifying to the existence and the great volume of the Gulf Stream at the North Cape, appears to me to be the temperature of the sea at Fruholm, which in January is in the mean still +37°.9. Fruholm is on the same parallel of latitude as Ust-Jansk in Siberia and Point Barrow in North America. The former has a mean temperature in January of —38°.6, the latter of —18°.6. Meran, in Tyrol, of world-wide celebrity, on account of its mild and temperate air, nearer to the Equator by twenty-four and a half degrees, has in January a temperature (of the air) of 31°.8, Venice 36°.3, Vevay 33°.1, and Paris 35°.4.*

* New York, 29°.5; Washington, 31°.5. See "Results of Meteorological Observations, 1854 to 1859, by the Smithsonian Institution."—Hydrographic Office.

Beyond the northernmost coasts of Europe observations of the temperature, in summer and winter, have been made in Nova Zembla and on Bear Island. On the former, Russians have wintered for scientific purposes several times within thirty-eight years, first Pachtussow, 1832–'33, at the Kara Straits, and 1834–'35 at Matotschkin Scharr, (Matthew's Straits;) then Moissejew, 1838–'39, in Shallow Bay.[93] There is less ice on the north coast of Nova Zembla than on the south coast,[94] and the highest temperature was found at the northernmost of the three meteorological stations, in summer and winter, as well as in the average throughout the year; the temperature there never was lower than —26°.5, but at the Kara Straits, three degrees south of the northernmost station, it fell to —40°.[95] The mean temperature of Shallow Bay (situated in latitude 73° 57′ N.,) in January, +9°.5, is also that of Quebec, (latitude 47° 00′ N.,) on the west side of the North Atlantic; and at Nain, in Labrador, (latitude 57° N.,) it is as low as —2°.4.

On Bear Island the Norwegian fisherman, Sievert Tobiesen, has observed the temperature during the entire winter, from August 6, 1865, to June 19, 1866, three times daily—at 8 a. m., 2 p. m., and 8 p. m.—at his own expense. I have appended these very meritorious observations in full at the end of this memoir. Here I insert an abstract of the monthly means, together with those found at Shallow Bay, on Nova Zembla, in nearly the same latitude, for comparison; the two are the northernmost observations in the European Arctic Sea. I have also added those for Ust-Jansk, on the Siberian coast; of Point Barrow, the northernmost point of North America; of Mercy Bay, in the Arctic Archipelago of North America; of Rensselaer Harbor, Kane's winter station in Smith's Sound; and lastly of the North Pole, according to Professor Dove's computations:

Means of the temperature of the air.

Months.	Bear Island.	Shallow Bay.	Ust-Jansk.	Point Barrow.	Mercy Bay.	Rensselaer Harbor.	North Pole, (Dove.)
Latitude N....	74° 39′	73° 57′	70° 55′	71° 31′	74° 6′	78° 37′	90°
Longitude from Greenwich.	18° 48′ E.	54° 48′ E.	138° 24′ E.	156° 17′ W.	117° 54′ W.	70° 40′ W.	
	°	°	°	°	°	°	°
January.......	4. 1	9. 5	—38. 6	—18. 6	—35. 5	—29. 4	—26. 5
February......	16. 5	4. 2	—36. 0	—22. 4	—32. 1	—27. 4	—21. 1
March.........	6. 3	3. 2	—17. 5	—14. 6	—26. 7	—36. 4	—15. 3
April..........	13. 8	4. 7	— 0. 4	3. 4	— 4. 0	—11. 2	1. 0
May	24. 1	30. 0	16. 2	20. 1	10. 2	12. 9	15. 1
June	33. 8[96]	37. 6	37. 8	32. 2	31. 6	29. 3	27. 5
July	....	41. 0	52. 7	36. 2	36. 7	38. 1	30. 6
August	37. 1[96]	39. 0	49. 5	38. 3	35. 4	32. 4	27. 5
September.....	33. 8	31. 2	27. 5	25. 9	22. 5	13. 6	18. 5
October	27. 0	22. 7	— 2. 2	2. 3	— 0. 8	— 4. 9	0. 1
November	22. 3	0. 2	—22. 2	— 8. 5	—15. 7	—22. 9	—11. 2
December	16. 7	3. 4	—33. 0	—13. 2	—23. 1	—31. 9	—18. 0
Year......	....	18. 9	2. 7	6. 8	— 0. 2	— 3. 1	2. 3

Tobiesen's hut was on the northeast point of the island,[97] without any protection, exposed to wind and weather, especially toward the north and east, and the island is situated in the middle of the Polar Stream, which here deposits its masses of ice. Notwithstanding all this, the observations did show the highest temperature to be here, of all the places where observations were obtained in or near the same latitude in either the northern or the southern hemisphere. The average temperature of —3°.1, of all the days in the year, which Kane found in Rensselaer Harbor, is lower than the mean temperature of the coldest month on Bear Island. Ice did not become firm during the entire winter, but consisted of loose drift pieces driven by the winds in all directions. On Christmas day the temperature was +34°.2, and during the entire week, to January 1, the average was 32°.9, for the most time with westerly winds, which brought rain on four days. The absolutely lowest temperature (—19°.1) was observed January 8.

Already before Tobiesen, Norwegian walrus hunters had wintered repeatedly on Bear Island since 1824; they report of the year 1824 as follows:

Up to the middle of November the weather was mild; the snow, which fell at night, melted again during the day-time. In that year also there was rain at Christmas, and in the same week more than seventy walruses were killed by the light of the moon and the aurora borealis. Until February the weather was still so mild that the people could work outside; the sea was free of ice to such a degree that polar bears did not make their appearance on the island earlier than April, when the temperature reached the lowest point and the sea was covered with firm ice. The latter comes principally from the northeast, from the Siberian coast; but northeasterly winds had not blown, according to the journal, during the entire winter; very little ice, therefore, drifted to the island. The Gulf Stream, to all appearances, remained in preponderance during the winter toward the northeast, and the winds from that direction, blowing over the island, brought rain, even about Christmas time. But after the sun had risen again for the arctic central region, and with the gradual increase of the temperature, the ice broke loose from the places of its generation on the Siberian and other coasts, and started on its course toward the south. Most of the ice which reached Bear Island did not arrive earlier than June and in the beginning of July, and this also is the time at which, with great regularity, each year the coasts of Siberia become free of ice. Until this time all the winds from the northeast brought cold weather, because they had to pass over the Arctic Sea, but after that, the weather became mild with the same wind.[98]

According to the weather calendar for the year 1865–'66 one could row around the island in a boat until the end of October. November 6 no ice was to be seen, and the island and the surrounding sea were, more or less, free of ice at the following dates: 16th to 19th of November, 30th of November, 4th of December, 7th to 10th of December, 31st of December to 7th of January, 3d to 5th of February, 10th to 24th of February, 2d of March, 23d of March, &c.

While the mean temperature of the air in October at Tobiesen's winter hut was 27°, that of the water of the Gulf Stream, between the island and the Norwegian coast, was, for the same month, according to Von Otter and Palander, 46°.6, consequently 19°.6 higher; and while the January mean of the air fell to +4° the sea at Fruholm was still at 37°.8, and perhaps more at a greater distance from shore. No other region of the globe shows, within the same latitudes, such relations of temperature as those under the influence of the Gulf Stream, except perhaps East Greenland and Spitzbergen. In regard to East Greenland we have the following data of the expedition under Clavering and Sabine, which came to anchor August 13, 1823, under the lee of Sabine Islands in latitude 74° 30′ N. Leaving General Sabine at the observatory, Captain Clavering started, August 16, on an excursion with two small boats, which were rowed along the coast in fair weather. This excursion took twelve days, during which the crew each night slept in tents, covered only with coat and blanket, without suffering in the least from the cold. The temperatures from the 16th to the 28th were: mean 36°.5, highest 52°.2, lowest 23°.[9] On Bear Island the mean temperature from August 16 to 28, according to Tobiesen, was 36°.3.

In Germany (at Ratibor, in latitude 50° N.) last winter the temperature fell to a lower point (—25°.4) than it ever appears to have attained on Bear Island, (minimum in 1855-'56 only —19°.1.)

The climate of Spitzbergen is, according to all accounts, still milder than that of Bear Island. It is certain, and proved by observations, that the heat of the sun reaches a considerably higher point, even in latitude 80° N., than on Bear Island. Blomstrand observed July 16, 1861, in Wide Bay, (Wijde Bay,) on the north coast, in the shade 60°.8,[100] while Tobiesen, on Bear Island, saw only three times the thermometer rise to 43°.5, on the 6th and 17th of August and the 18th of September.

Parry, in 1827, found the mean temperature of the air in July to be 40°1.[101]

Of the temperature of Spitzbergen in the winter we have yet no observations, but the Norwegians and Russians, who have wintered there so frequently, describe "the winter as not so cold as at St. Petersburg."[102] There are to this day in all the bays (fiords) on all the coasts of Spitzbergen, many, some well preserved, others decayed, so-called "Russian huts" to testify that Russians have, during the last century and at least for the three or four first decades of this century, visited Spitzbergen in considerable numbers to hunt the walrus, seal, whale, bears, and foxes. They had their principal stations, where they remained the entire year, or else sailed in August to Archangel and returned in April. In the vicinity of the large stations they had smaller huts, where they found shelter when hunting. Such Russian establishments the members of the Swedish expeditions found everywhere in their explorations of Spitzbergen: at Stans Foreland, at the South Cape, in Horn Sound, (one evidently intended to house twenty men, and two smaller ones, each for five men,) in Bell Sound, in the Ice Fiord, Green Harbor, Prince Charles Foreland, in Cross Bay, in Hamburg Bay, on the main opposite Amsterdam Island, on the north coasts of Red Bay, Wide Bay, Mossel Bay, and on the Northeastland. Norwegians have wintered in Spitzbergen since 1822.[103] The Russian Starastschin wintered in Green Harbor, in latitude 78° N., not less than thirty-nine times, once during fifteen successive winters. He finally died there of old age in 1826. "It may be boldly asserted," so it is stated in the report of the Swedish expedition in 1864,[104] "that no healthier and more salutary summer climate can be found on the globe than that of Spitzbergen. During three summers, in which Swedish expeditions have visited this region, there has no case occurred among the officers and crews of catarrh, diarrhœa, fever, or any other sickness."

In Kobbe Bay (latitude 79° 41′ N.) the Swedes found the ice of a lake only six feet thick, and beneath it water of twelve to fourteen feet in depth, the temperature of which was at the bottom 34°, on the surface 32°, and at the depth of half a foot 32°.4. The bottom was covered with a thick layer of green slime, consisting almost exclusively of siliceous algæ, diatomaceæ, and others of lower orders, oscillatoriæ, and desmiadiaceæ; among these there were living a species of larva, chironomus, microscopic crustacæ, cyclops, and smaller worms. "From this a conclusion may be arrived at with certainty that the winter is not very cold."[105]

In Cross Bay (79° 15′ N.) the Swede Andrew Lindström wintered, with twenty-four men, 1843-'44. Cold weather did not set in before New Year, and it reached its maximum with the end of the long winter night During the winter northerly winds were prevailing; in spring and autumn they were westerly and southerly. The sea remained open until New Year, when the drift ice arrived; then the sea froze, in calm weather, but the ice was torn from time to time by storms.[106]

That in East Greenland also the winter is remarkably mild has been proved by the Danish Captain Graah, who wintered in Nukarbick (latitude 63° 21′ N.) 1829–'30, and whose experience cannot be compared in the remotest degree with that of the English expeditions among the confused mass of islands and on the coasts of the American side. On the 29th of October he had still rain, and very mild weather to the end of February, when it became colder, but the lowest temperature was —4° and —6°. In November and December there were a few days of from +14° to +9°.5. In February and March the sea was free of ice in a distance of twelve to fifteen miles from the coast.[107]

4.—THE GULF STREAM AT ITS NORTHERN EXTREMITY, AS FAR AS EXPLORED.—THE NORTH POLAR EXPEDITIONS.

The facts enumerated in the preceding pages are the effects of the Gulf Stream in these high latitudes on the coasts and islands washed by it or in its vicinity. The course of the Gulf Stream north of Iceland and Europe is more complicated than to the southward of these coasts. After coming forth intact from its two struggles with the Polar Stream east of Newfoundland and east of Iceland, its waters are cooling more and more toward the north, until they are reduced to a temperature of 39°.4, when they attain their highest density and greatest weight. At this temperature it sinks beneath the Polar Stream, in July, north of Iceland and Spitzbergen and on both sides of Bear Island. Beyond the sea-isotherm of 36°.5, (2° R.,) that is, from the curve at which on Chart No. 1 the lightest blue ceases and the white area begins, the Polar Stream preponderates decidedly, or at least runs *over* the immersed Gulf Stream, and this takes place partly already within the lightest blue, between the isothermal lines 36°.5 and 41°, (2° and 4° R.) The line separating the Gulf Stream from the Polar Stream is, for the most part, sharply defined. As far as the former reaches, the color of the water is of a beautiful azure blue, and fin-back whales, which do not frequent the colder water, follow ships as far as the sea retains that color; the Polar Stream, on the contrary, shows a dingy green color, caused principally by a multitude of microscopic, slimy, and badly smelling algæ of the families of diatomaceæ and desmiadiaceæ.

In the discussion of the vertical relations of the temperature of the sea, (that at the various depths,) the submerging and the rising of currents, or the arrangement of warm and cold strata of water over each other, must not be left unnoticed, in order to avoid hasty conclusions as to the volume of the uppermost stratum. North of the isothermal curve of 39°.4 (3°.3 R.) toward the pole, the temperature generally increases with the depth, while southward toward the Equator it decreases. There is, however, no uniformity in this, so that, for instance—as Lieutenant Rodgers, in 1855, found in the Asiatic part of the Arctic Ocean—there is on the surface a warm current with water of a low specific gravity, beneath it a cold current, and then again a warm current of heavier water, and all these strata running in opposite directions.

The Gulf Stream sets, north of Europe, in its main direction toward the northeast and reaches Bear Island and the extensive shallow bank from which the latter crops out.[108] For the third time it meets here the Polar Stream, coming from the opposite direction, the northeast, and not, as eastward of Newfoundland and Iceland, laterally or about under a right angle. It therefore does not press the Gulf Stream to one side, but cuts it into two branches, one of which proceeds northward along the west coast of Spitzbergen, the other eastward of Bear Island. This latter is the principal arm, the Spitzbergen stream a side branch, a blind alley, which has deceived many a ship penetrating there and finally turned back by the Polar Stream, which, close to the north coast of Spitzbergen, blocks the way of this lateral branch effectually.

The temperature observations of Lord Dufferin, Koldewey, Nordenskiöld, and Bessels show that this branch is not only separated at Bear Island from the main arm, but also pushed far toward the west, and probably entirely cut off, at least in July. The temperature here sinks rapidly from 45° and 41° to 32° and below 32°, the Polar Stream pressing into the Gulf Stream, according to the observations thus far obtained, with a double tongue.

That this western and weaker arm of the Gulf Stream is conquered in the height of summer by the Polar Stream at Bear Island, is not to be wondered at, as the latter is extraordinarily voluminous and strong. Koldewey found its force between the parallels of 75° and 76° N., in the first days of July 1868, to be thirteen miles a day,[109] but at the southeast point of Spitzbergen, where it sets sharply against the coast from the northeast, its force is much greater. Lamont, who staid there the entire July and August of 1859, made interesting observations regarding it. At Black Point, a cape of Stans Foreland, which is even less exposed to the Polar Stream than the Thousand Isles, (compare Chart No. 2,) it passed with such force that six men could not row a boat against it. Lamont states it to be there three miles per hour, or seventy-two miles a day. At the Thousand Isles it is still more powerful, at times 168 to 192 miles a day.[110]

That the Polar Stream between Spitzbergen and Bear Island sets with great strength westwardly, against the coast of East Greenland, is further proven by the circumstance that, according to the experience of whalers and sealers, there is always to be found a deep bight in the ice between the parallels of 74° and 76° N. On this experience rests my advice to the first German North Polar Expedition, in 1868, to penetrate to the east coast of Greenland, in the latitude of this bight, between 74½° and 75° N [111] The Royal Geographical Society of London published, in 1868, the plan of that excellent Scottish mariner, Captain Gray, whose opinion fully coincides with my own when he says:

Having for many years pursued the whale fishery on the east coast of Greenland, and observed the tides, the set of the currents, and the state of the ice in that locality, at various seasons of the year, I think that little, if any, difficulty would be experienced in carrying a vessel in a single season to a very high latitude, if not to the Pole itself, by taking the ice at about the latitude of 75°, where generally exists a deep bight, sometimes running in a northwest direction upward of one hundred miles toward Shannon Island, &c.[112]

There would be no motive for this bight if the Polar Stream was not pressing deeply into the west, in the latitude of Bear Island. Dr. Dorst has cruised, in Rosenthal's steamer Bienenkorb, for five months in this same region, between Shannon and Bear Islands and between Jan-Mayen and Spitzbergen, making observations of all kinds each alternate hour, and, among other things, he has prepared a very excellent ice chart, which I have at hand.[113] The latter shows to the westward of Bear Island, in the drift ice as well as in the heavy field ice, a deep bay toward East Greenland, which, from March to August, cuts progressively deeper, until it nearly reaches the east coast of Greenland. The indentation of this ice bay, or the destruction of ice, reached, during the five months of Dorst's cruise, over not less than 250 or 300 nautical miles. I have indicated the bay on Table 18 accompanying the "Geographische Mittheilungen" of 1869; its southwestern limit is marked by an ice edge of 230 miles in length, which extends from Jan-Mayen in a west-northwest direction. When the complete results of Dr. Dorst's observations are published these facts will appear more clearly.

Koldewey's observations, in the mean time, are sufficient to establish this current from east to west. They show that on the parallel of Shannon Island to about longitude 11° W. of Greenwich, it has still a west-southwest direction and a velocity of eleven miles a day, (compare the observations of June 30,) and not until here it meets the East Greenland ice current, which, coming directly from the north, now takes a south-southwest and south by west ¼ west course; (compare the observations of June 8, 28, and 29.)[114]

A very striking confirmation of the existence of this westerly Polar Stream between Bear Island and Shannon Island is found in Koldewey's observations of the driftwood met by him. He found such exclusively between the latitudes of the south point of Spitzbergen and of Jan-Mayen, just where this stream prevails, sometimes in great quantities, and it is evident that it comes there directly and in a straight line from the north coast of Nova Zembla, to which it drifts from the great Siberian rivers Obi, Jenisei, and Lena, which, again, carry it from a great distance, even from the far, wooded south, near the Chinese border.

Koldewey's records of the color of the sea indicate clearly that Gulf Stream water also is pressed by the Polar Stream far to the west, close to the coast of Greenland. As high as latitude 74° N., in longitude 14° W. of Greenwich, but seventy miles from the east coast of Greenland, he observed the sea striped blue and green; the former known to be the color of the Gulf Stream, the latter of the Polar Stream.

At the south point of Spitzbergen the Gulf Stream is still discernible, at least at times, proceeding in a sharp turn around the cape toward the Thousand Isles, as I have already stated in another place.[115] To the north and east of the Thousand Isles the Gulf Stream, according to Lamont, the best authority for this region, has little or no influence at all, and the polar ice drifts there always vehemently toward the southwest. But as soon as it arrives at the westernmost of the Thousand Islands it gets into the warm water of the Gulf Stream and is rapidly dissolved.[116] Such is still the influence of this weaker arm of the Gulf Stream against an exceedingly violent polar current in this high latitude of 77° N., about six thousand miles from its source in the Florida Straits.

In regard to the currents and the ice in these regions during the winter, it appears from the accounts of the Norwegians, who have wintered on Bear Island, that most of the ice does not arrive at the latter before the spring and summer.[117] Captain Jansen, in an interesting account compiled from the voyages of the earlier Dutch navigators, remarks: "In a common year the south cape of Spitzbergen remains, even in winter, free of ice; but after a severe winter it may be for some forty or fifty miles to the southward of it surrounded by broken ice."[118]

The thermal observations of Tobiesen at Bear Island show that, at least in 1866, the relatively greatest amount of ice, accompanied by the lowest temperature, arrived at the island in March and April, and that it came from the northeast.

Up to Bear Island, Spitzbergen, and Nova Zembla, therefore, the Gulf Stream is readily discernible; the question remains, now, whether it exists beyond these islands toward the Siberian coast. In regard to this I wrote in April 1865 as follows:

> Although the physical atlas and the charts of the world show exactly here, from Spitzbergen and Nova Zembla to the New Siberian Islands, the thickest and most permanent ice in the world, blocking up all the Taimyr coast, yet already the observations of Von Middendorf have demonstrated how erroneous this supposition is, which, a mere fancy, has held, up to our day, so rigid a sway over all the geographical text-books and charts. This eminent traveler was prepared—from old accounts and for the reason that great and nearly permanent masses of ice are known to exist in the more southern Kara Sea—to find, also, the Taimyr Bay full of ice, or perhaps frozen throughout; but how agreeably was he surprised when he saw it so entirely free that he could not discover even the smallest particle of ice![119]

If there were no observations but his for this region, then the facts found by him might be considered an exception from the rule, the result of an extremely favorable season; the sea, however, eastward of the Taimyr land and north of the New Siberian Islands has, close to the shores, always been found open, as often as these islands were visited, since 1810, by Hedenström, Tatarinow, Wrangell, and Anjou.[120] Hedenström reports:

> To the north of the islands, in latitude 76° and beyond it, the ocean never freezes. Even in March, (when at the not very distant Ust-Jansk the mean temperature is —17°.5,) I have seen there but very little drift ice. This is the place from which the exploration of the northernmost islands off America and of the north part of Greenland should be started, to promise success, and from which the North Pole might possibly be reached in a ship.[121]

Wrangell's book is so well known, and so readily accessible, that there is no need to recapitulate here its details in regard to this always open sea; it is sufficient to add that the prevailing current is shown to run from the westward to the east and southeast, in the direction of Cape Jakan, where the Polynja reaches closest to the coast. Already in 1852 I expressed the opinion that this Polynja is but an extension of the Gulf Stream. In forming conclusions in regard to this, it must be kept in view that the New Siberian Islands and the open sea lie directly north of the absolutely coldest region of Siberia, which may be denoted by a line from Jakutsk to Ust-Jansk, a region, although extremely cold in winter, yet with a very high temperature in the midst of summer, when the neighboring coast is free of ice. At Ust-Jansk (latitude 70° 55′ N.) Hedenström observed, July 6, 1810, in the sun, 117°.5.[122]

That the Gulf Stream really extends to the coasts of Siberia has not yet been established incontrovertibly, but much has been added of late to our knowledge of this region by three of the expeditions to the North Pole since 1865.

Captain Palliser penetrated, in the last days of July 1869, without difficulty, to about thirty miles north of Cape Nassau, the northwestern point of Nova Zembla, and expressed the opinion that he could have sailed, without great danger, entirely around Nova Zembla, from doing which he was prevented by other circumstances.[123]

Captain Johannesen came, as early as the 19th of June, 1869, within sight of the same cape, a mile to the north of which he found the border of the field ice, which, however, was very thin; there appeared to be no ice to the eastward, and a strong current was setting in the same direction. "I had," so Captain Johannesen states expressly, "nowhere to the south observed so strong a current as that at Cape Nassau."[124] This strong current corresponds entirely with the direction and the prolongation of the Gulf Stream, and the thin ice so high north with the influences of the latter.

The most valuable of all the observations obtained so far in the great sea between Spitzbergen and Nova Zembla are those by Dr. Bessels, who crossed it twice in Rosenthal's steamer Albert during August 1869, observing every fourth hour.[125] The meridian of Bear Island divides the Northern Sea into two equal parts; there are thirty-six degrees of longitude between it and the east coast of Greenland, and as many between it and Nova Zembla. The course of the ship on her return from Nova Zembla was mainly on the parallel of 74° N., and the temperature there in the last days of August was found to be throughout from 38°.8 to 42°.1, while on the same parallel west of Bear Island, except at a single point crossed by Dufferin, it fell in July (according to Dorst and Dufferin) to the freezing point, (32°,) and below it—a very considerable difference.

Now, although the temperature on the parallel of 75°, near Nova Zembla, is on the average as low as 36°.5, there is the remarkable fact that, exactly where the Gulf Stream might be looked for, viz., immediately east of Bear Island, north of latitude 75° and beyond 76° N., as far as Bessels penetrated, it reaches 42°.4, by which fact the extension of the Gulf Stream into these regions is satisfactorily proved. We do not know yet how high it really ascends, but further north it surely comes again in collision with the Polar

Stream and with the drift ice. Dr. Bessels found the border of the field ice, in August 1869, between Hope Island and Nova Zembla, on the average between latitudes 76° N. and 77° N.

How the Gulf Stream, apparently destroyed by the Polar Stream, nevertheless continues on its course may clearly be seen at Spitzbergen. The branch proceeding there to the north, as we already know, is at Bear Island, in latitude 74° N., completely cut through by the Polar Stream, so that, up to the southern point of Spitzbergen, the latter, in a width of about 140 miles, preponderates entirely, and compels the warm water to sink beneath it. But immediately under the lee of Spitzbergen the Gulf Stream, now protected against the Polar Stream, rises again to the surface, which then has a temperature of 41° and more, while the sea in the neighborhood, to the southeast, is below 32°. In that manner this western branch continues along the entire west coast of Spitzbergen, and, although the weaker one, presses still on, north of that island, deep into the Central Arctic, up to latitude 82° and beyond. There it has been observed by Parry, in July and August 1827, whose observations in regard to it reach higher north, and are more accurate than all the others obtained thus far. He traced it on the meridian of 18° E. of Greenwich up to latitude 81° 55′ N., and on the meridian of 21° E. of Greenwich to about latitude 82° 20′ N. Following its somewhat curved course from the place in 74° N. where it appears to be destroyed, to the northernmost observations of Parry, this part will be found of a length fully equal to ten degrees of latitude.

When, now, this western weaker branch of the Gulf Stream, after its apparent destruction in latitude 74° N., west of Bear Island, is still found at such a distance, and when the main arm east of the island has, in latitude 76° N., still a temperature of 42°.4, should this not justify the assumption that the latter extends eastward toward Siberia about as far as the other extends west and north of Spitzbergen?

We see that the Gulf Stream in its struggles with the Polar Stream is temporarily conquered, and compelled to sink beneath it; but we also see that it remains strong enough to rise again to the surface.

I will state here at once, emphatically, that I do not base upon the existence and extent of the Gulf Stream in these regions favorable chances for an expedition to penetrate into the Arctic; quite the contrary is the case. The further north the Gulf Stream maintains its preponderance over the Polar

Current, presses it back, or detains it, the more will the masses of ice, seeking an outlet, accumulate and form a powerful ice-belt, which will be found, corresponding to the permanency of the two streams, in all probability at all times, and always of about an equal thickness, and at pretty nearly one and the same place. To penetrate toward the North Pole by the branches of the Gulf Stream east or west of Spitzbergen which extend furthest into the Arctic, and to break through the pack ice, appears to me more difficult than to press into the Polar Stream, in which, on account of its outlet southwardly, the ice distributes more readily and is not apt to pack. The two routes may be compared to mountain passes to be crossed: a long, uniformly-inclined valley leads to the one, the elevation is throughout gradual, and therefore easily overcome; the road to the other, of the same height, goes through a but little inclined valley, closed by a high and steep bluff, which to surmount is exceedingly difficult, if not impossible.

When urging the expeditions to the North Pole and discussing them, I have therefore earnestly advocated not to choose the route along the west coast of Spitzbergen, as I believe it to lead into a blind alley of ice. To cross the sea between Spitzbergen and Nova Zembla should, in my opinion, only be attempted by a thorough sailor, who is as familiar with ice belts as, for instance, Sir James C. Ross. If Koldewey, in his attempt toward Gillis Land, in July 1868, had proceeded along the southeastern coast of Spitzbergen, he would have been able to penetrate further; surely at least as far as Burgomaster Löwenigh in 1827, or Lamont in 1850, or Birckbeck and Newton, 1864.[126] Koldewey only spent three days in the attempt to break through by the south cape of Spitzbergen, and then gave it up; a time entirely insufficient for an ice belt or an ice stream. It took James Ross, when breaking through the ice belts around the South Pole, at one time not less than forty-six days, from the 18th of December, 1841, to the 2d of February, 1842, to work through an ice stream of about five hundred miles in width; but he found on the other side of it a great open sea, free of ice.[127] If Koldewey had persevered but one day longer, he would probably have reached the warm stream of Dr. Bessels.

Even if it may be quite difficult to penetrate here toward the north, this sea nevertheless surely deserves more attention than heretofore has been accorded to it, as the history of the polar expeditions proves that ice streams, such as those met here, open at times, and are never impenetrable for a good seaman. It is, therefore, much to be regretted that the expedition projected for

1870 in the sailing yacht Germania, (*alias* Greenland,) which I have been able to purchase from my collections of 1868, had to be postponed. Dr. Bessels and Dr. Dorst, the two well-tried polar voyagers, and Captain Wyprecht, one of the earliest friends of German polar exploration, were anxious to extend the valuable researches of Dr. Bessels in this region, and were even prepared to provide from their own means for the scientific equipment. I have always pointed to the exploration of this region as of the highest importance, and have (July 30, 1865) even offered a premium for it of from one thousand to two thousand dollars.[128]

To attain results in the Arctic requires, besides nerve, perseverance such as shown by James Ross, Johannesen, and others. Much will depend on these qualities, also, on the east coast of Greenland. The expedition of 1868 was instructed by me[129] to try whether it could reach the coast between the parallels of latitude 74° and 76°; but I did not exclude a higher latitude as far as 80°. Unluckily this has been neglected, and not the slightest attempt has been made by Koldewey between latitudes 76° and 80°. It is still very questionable whether it would not be less difficulty to reach the coast between 76° and 80° than between 74° and 76°. Although there is, between the latter, always a bight of open water cutting deeply into the ice toward the west, this bight is caused directly by the pressure of the Polar Stream and the polar ice of Bear Island, and it is therefore not improbable that the route between 76° and 80° may prove the easier. Scoresby, in his brilliant voyage of discovery in 1822, could not reach the coast on the parallel of 74°, but he had perseverance enough to work for six weeks through the drift ice, and found his reward by reaching the coast further south, whence he could work along it toward the north.

We know now the most weighty facts (but not yet sufficiently considered and valued) to prove that the Gulf Stream does not cease or sink and disappear entirely between Spitzbergen and Nova Zembla. Going from there to the regions of Northeast and New Siberia, discovered and explored by Hedenström, Tatarinow, Sannikow, Wrangell, Anjou, and others, we first come to Taimyr, the northernmost land of Siberia, the winter of which, as far as Von Middendorf could ascertain, is relatively very mild, decidedly milder than further south, and abounds in fish.[130]

On the ice and the climatic properties of Northwest Siberia in summer new light has been shed by the cruise of the Norwegian fisherman, Johannesen,[131] and by those of Palliser and Carlsen in 1869.[132] Their accounts fully agree with the experience of Lopatin in 1866:

No ice was found (July and August 1866) by Lopatin in the Jenissei Bay, where, in latitude 72° N., it meets the Arctic. The Dolganes living in the vicinity assured him that they never find ice when arriving at the bay in the last part of summer. Russian settlers stated that in summer ice is seen on the sea only with winds from the west and northwest, never when the wind blows from the north and northeast. It is remarkable that the members of the expedition who penetrated to the sea on the right bank of the mouth of the Jenissei could never leave off their winter clothing, while those who were occupied on the west side suffered from the heat and from myriads of mosquitoes.[133]

Already Von Middendorff had seen at the northernmost point of Asia, in summer, 1843, the Arctic, lying before him, completely open and so free of ice that he could not detect the smallest piece.[134]

That there is, in general, north of the entire coast of Siberia, as high as it has been possible thus far to advance, from 70° to 76°, a "never-freezing open sea," with "but very little drift ice,"[135] even in the coldest month, is a fact which for sixty years past has been examined into over and over again, and always found to be true; in winter time by Hedenström, Tatarinow, Sannikow, Wrangell, Anjou, and others; in summer by Johannesen, Palliser, Carlsen, Lopatin, Middendorff, Kellett, Rodgers, Long, Mohr, &c.—a fact the more remarkable as that sea lies north of the coldest region of the world.[136] There has so far been only one single expedition on the broad Arctic for the expressed purpose of exploring the polar domain, that of Wrangell, of four years' duration. This expedition, starting from the coldest land of the world in the month when the ice was thickest, and following a northern course on a very shallow sea, found the ice to be getting, step by step, thinner and more broken, until it came to an entirely open sea, at one place at a distance of five Russian werst or three nautical miles from the shore.[137]

The average temperature of the Siberian Arctic Sea east of the mouth of the Kolyma, for the summer, is, according to the observations of Wrangell, in July, 37°.6; in August, 37°.0.[138]

The current observations of Wrangell in Northeast Siberia exhibit the following remarkable facts: The currents in that region, as is known, set in spring and summer to the west, in fall and winter to the east,[139] in the direction of the Gulf Stream. The preponderance of the latter direction is evident from the fact that Wrangell, on his third voyage, March 26, 1822, in latitude 72° 10′ N., longitude 166° E. of Greenwich, found on the drift ice the traces of his sleigh which were impressed there in April 21, geographically to the westward of the present position, (as he says, thirty-five werst or twenty miles, but as I make it, seventy werst, or double the distance;) the current here was east-southeast.[140]

5.—DRIFT WOOD IN THE ARCTIC.

Of more importance than all these observations is the existence and the diffusion of drift wood in the Arctic Ocean, one of the most remarkable phenomena. Dr. Oscar Peschel says appropriately:[141]

> Just as Columbus inferred the existence of a continent in the far west from the tropical wood which he saw drifting into the Canaries, with the same certainty we may conclude, from the Siberian logs which we find on the coasts of Spitzbergen, that the Arctic bordering Siberia throws off its ice. North of Siberia and east of Spitzbergen the sea must be free in summer, that the drift wood carried down the Obi, the Jenissei, and the Lena, may reach Spitzbergen.

The same author remarks, further:

> Although Swedish naturalists say, without arguments for proof, that this wood is carried there by the Gulf Stream, we rather would take it to be from Siberia, for geographical reasons, as the Gulf Stream could not possibly throw it on the east coasts.

The Swedes found, especially on Northeastland, huge masses of drift wood and other drift produce, for instance, on Shoal Point, the westernmost cape, a low sandy point.[142] They reported:

> The shore is covered everywhere with an incredible mass of drift wood, among which are pieces of pumice-stone, birch bark, cork, raft wood from the Lofode Islands, and other articles carried there by the current. The drift wood was piled in a long line along the shore. Higher up was another wall, which the water could hardly reach, even in spring tides. The wood constituting this wall, which probably had been lifted together with the coast, was older and on the point of crumbling to decay. Torrel, when examining all this, found, among other things, a well-preserved bean of "*Entada gigalobium*," a West Indian legume. This bean, about one and a half inches in diameter, carried by the Gulf Stream across the Atlantic Ocean, is frequently thrown on the coasts of Norway, and, in this instance, offers the best proof that the Gulf Stream also reaches the north coast of Spitzbergen.

The shores also of the Seven Islands, in their lower parts, were found covered with drift wood, ship timber, a great quantity of pumice-stone, birch bark, raft wood, timber marked with Roman letters, and remains of whale skeletons, &c. There are also great quantities of drift wood found on Castrén Island, at Cape Lovén, as well as along the entire north coast of Northeastland, at Low Island, in Lomme Bay, on the coast of the Westfiord in Wide Bay, on Moffen Island, and on the southernmost cape of Spitzbergen. On the west coast and in Wide Jans Water single trunks of trees and logs are found but exceptionally.[143]

The Swedes contend,[144] with good reason, that the drift products of the West Indies, such as *Entada gigalobium*, are the best proof that the real Gulf Stream extends to the northeast coast of Spitzbergen. But it is not less interesting that all the vast masses of drift wood come from Siberia, and that each single piece of it is an equally sure and unmistakable proof establishing the fact that the Arctic between Spitzbergen and Siberia gets open sufficiently to permit its reaching there.

We have seen that the meeting of a polar with an equatorial stream causes drift ice, as at Newfoundland; we also have seen that the drift ice may pack near the place of meeting, so as to form an ice belt more or less permanent, as for instance north of Spitzbergen and between Spitzbergen and Nova Zembla; hence we may infer conversely from the drift wood, &c., which we find on the northernmost coasts of Spitzbergen, a meeting there of the Gulf Stream with the Polar Stream, and we may further conclude that the Gulf Stream extends to the north coasts of Northeastland and to the Seven Islands. The Swedish memoir says: "Only when we had reached Cape Wrede, one of the northeasternmost capes of Spitzbergen, no more things belonging to Norway were found, except a few harpoons and oars, which probably were carried there by the coast current." There was, however, also here, on the most remote parts of the Northeastland, abundance of drift wood.[145]

From this it appears probable that the Gulf Stream does not reach these coasts, but that they are reached by the drift wood of the Siberian rivers.

The opinion of Swedish writers that the drift wood found at Spitzbergen is carried there by the Gulf Stream has, of late, been adopted very generally. But as early as 1852 I expressed publicly my conviction that it comes exclusively from the Siberian rivers, and is carried not only to Spitzbergen but also to Greenland.[146] Irminger said, as early as 1854, that in his opinion much of the drift wood thrown on the north coast of Iceland comes from Siberia.[147]

Lamont also, who in 1859 found vast masses of drift wood everywhere in Southeast Spitzbergen and on the Thousand Islands, says positively that it consisted, without exception, of pine wood, which doubtless comes from Siberia.[148] Birkbeck also, and Newton, who in 1864 penetrated to the Ryke-Ise Island, express their belief that the drift wood found there comes from Siberia, and is not carried there by the Gulf Stream.[149]

In view of the importance of this subject, I added to my instruction for the first German North Polar expedition of May 8, 1868, in section 25, the following:

An interesting and important result of the Polar Current is the drift wood of the arctic regions, found sometimes in vast masses, especially on all the coasts which either lie toward Siberia or are exposed to the currents coming from Siberia. Of this drift wood the greatest possible number of specimens should be taken on board and marked as to the place where they were found, so that after the return of the expedition inquiries might be made into their origin and conclusion arrived at in regard to the currents.[150]

Koldewey staid near the southern end of Hinlopen Straits from August 22d to September 10th, fully three weeks, and found there great quantities of drift wood.

The specimens of drift wood brought home by the Swedish expedition were examined carefully by J. G. Agardh, who has proved beyond contradiction that not a single piece of it belongs to any other species of wood than the Siberian *larix*, and that consequently none of it could have been carried there from southern regions through the Gulf Stream, but that all came from Siberia.[151]

6.—THE OBSERVATIONS OF DEEP-SEA TEMPERATURE—DRIFT CURRENTS AND WINDS—THE BRITISH SOUNDING EXPEDITIONS OF 1868 AND 1869.

Although the temperature and the currents at the various depths of the ocean are of the very greatest importance, I cannot now, for want of space, discuss them more fully, but must confine myself, for the time, to the surface. To establish the great streams rolling along on the surface of the ocean and their properties is, at present, the main problem. If these are complicated, and but very imperfectly known, how much more must this be the case with the same phenomena at greater depths, where there are relatively but a few isolated observations.

In entering upon the question it must be borne in mind that water is heaviest at a temperature of 39°.2,[152] and that it arranges itself in the various depths according to the specific gravity in strata, either above and beneath, or alongside each other. From the place where the sea shows at the surface a temperature of 39°.2, it will lose in temperature toward the Pole, while in general it will gain with the increase of depth, but toward the Equator the temperature of the surface will increase, while it will decrease downward in proportion.

A useful and interesting table of average temperatures of the ocean from 80° N. to 80° S., at the surface and at various depths to two thousand fathoms, has lately been prepared by Keith Johnston, jr. It is based on more than seven hundred observations, nearly all in the Atlantic Ocean, by the following observers: Ross, Lee, Chimmo, Carpenter and Thomson, Scoresby, Franklin, Parry and Fisher, Dayman, Shortland, and Fitzroy. The means are given of the observations for each tenth degree of latitude as follows:[153]

Depth in fathoms.	North Pole.	North latitude.								Equator.	South latitude.								South Pole.
		80°	70°	60°	50°	40°	30°	20°	10°		10°	20°	30°	40°	50°	60°	70°	80°	
Surface	32.4	29.7	52.9	50.0	66.0	72.0	76.1	77.0	79.7	79.7	76.1	76.1	59.0	53.0	40.0	30.0	30.0		
100		29.5	44.0	49.0	57.0								54.0	47.0	40.0	35.0	33.0		
200		33.0	48.0	42.0		65.0	70.0	70.0	69.0	68.9					40.0		34.0		
300					55.0							55.0	49.0	45.0	40.0	37.0	35.0		
400	31.0		33.0		49.0	63.0	66.0	68.0	64.0	65.0		52.0	44.0	43.0	40.0	38.0	36.0		
500			38.0		39.0								46.0						
600			46.0			43.0	63.0	69.0					42.0	43.0	40.0	39.0	38.0		
700		37.0											40.0	41.0		39.4			
800																			
900											40.1			40.0		39.4			
1,000				40.0	41.0	37.0								40.0	39.4	39.4			
1,200											39.4			39.4	39.4	39.4			
1,300								39.4											
1,500					49.0														
1,800								39.6											
1,900								33.6											
2,000					42.0														

We will inquire now into a few of the observations of deep-sea temperature within the limits of the Gulf Stream. Parry, in latitude 57° 51′ N., longitude 41° 05′ W. of Greenwich, on the 13th of June, 1819, observed the sea to have a temperature on the surface of 40°.5, and at a depth of 235 fathoms, 39°; the Gulf Stream therefore had there, one hundred and thirty nautical miles south-southeast of Cape Farewell, a depth of at least 1,410 feet.[154]

One hundred and forty miles northeast of this place, in latitude 59° 35′ N., longitude 38° 09′ W. of Greenwich, Captain Knudsen, on the 30th of June, 1859, found the temperature of the surface 44°.6, and at 300 fathoms 43°.4, which corresponds with Parry's measurements.[155]

Wallich remarks that on the parallel of latitude 63° N., not far from the south coast of Iceland, the temperatures on the surface and at a depth of 100 fathoms differ in the average not more than 3°.8; "that consequently the Gulf Stream does not lose essentially in temperature to that depth."[157]

On Irminger's chart of the currents and ice drifts around Iceland there is in Brede Bugt, (Broad Bay,) in latitude 65° 17′ N., longitude 23° 25′ W. of Greenwich, (about eighteen miles northwest of Stykkisholmr,) a temperature recorded of 46° at the surface and of 45°.5 at a depth of 60 fathoms. The Gulf Stream at this place, in the vicinity of the polar circle, is therefore at least 360 feet deep.[158]

Scoresby during the years from 1810 to 1817 has made the following observations between the parallels of latitude 76° N. and 80° N.[159]

Scoresby's observations of deep-sea temperatures, 1810 *to* 1817.

Date.	Position.		Sea.				Temperature of air.	Situation of the ship.
	Latitude N.	Longitude from Greenwich.	Depth in feet.	Temperature.	Specific gravity.	Color.		
	° ′	° ′						
April 19, 1810	76 16	9 00 E.	Surface..	28.8	1.2061	Blue	12	Beset in ice.
			300	31.8	....	....do		
			738	33.8	1.0270	....do		
			1,380	33.3	1.0269	....do		
April 23, 1810	76 16	10 50 E.	Surface..	28.3	....	....do	16	Frozen up.
			120	28.0	....	....do		
			300	28.3	....	....do		
			738	30.0	....	....do		
April 23, 1811	76 34	10 00 E.	Surface..	30.0	1.0265	....do	25	Frozen up.
			120	31.0	1.0264	....do		
			240	35.0	1.0266	....do		
			360	34.0	1.0268	....do		
			600	34.7	1.0267	....do		
May 1, 1811	77 15	8 10 E.	Surface..	29.3	1.0267	....do	16	Beset in ice.
			120	29.3	....	....do		
			240	29.3	....	....do		
			360	30.0	....	....do		
			600	30.0	....	....do		
May 20, 1813	77 40	2 30 E.	Surface..	29.0	1.0267	Greenish	30	Among floe ice.
			300	29.3	1.0265	....do		
			660	31.0	1.0262	....do		

Scoresby's observations of deep-sea temperatures, &c.—Continued.

Date.	Position.		Sea.				Temperature of air.	Situation of the ship.
	Latitude N.	Longitude from Greenwich.	Depth in feet.	Temperature.	Specific gravity.	Color.		
	° ′	° ′						
May 20, 1816	79 00	5 40 E.	Surface..	29.0	....	Olive green..	34	Moored to a floe.
			78	31.0	....	....do		
			222	33.8	....	....do		
			342	34.5	....	....do		
			600	36.0	....	....do		
			2,400	36.0	....	....do		
May 21, 1816	79 04	5 38 E.	Surface..	29.0	1.0269	....do	38	Among floe and field ice.
			4,380	37.0	1.0265	....do		
June 7, 1816	80 00	5 00 E.	Surface..	29.7	....	....do	40	Beset in the ice.
			720	36.3	....	....do		
June 7, 1817	78 02	0 10 W.	Surface..	32.0	....	Blue	36	In the vicinity of ice.
			4,566	38.0	....	....do		

Scoresby remarks: "From the fact of the sea near Spitzbergen being usually six or seven degrees warmer at the depth of one hundred to two hundred fathoms than it is at the surface, it seems not improbable that the water below is a still farther extension of the Gulf Stream, which, in meeting with water near the ice lighter than itself, sinks below the surface, and becomes a counter under-current."[156]

This assumption appears, on first sight, not to be supported by the observations of Koldewey;[160] but when the temperatures of the surface and the gravity of the water are properly considered they accord well enough.

I must postpone, however, as already stated, the especial investigation of deep-sea temperature to another occasion, perhaps until the return of the second German North Polar Expedition, which, it is hoped, will add materially to the data now at hand. I will here only now discuss in a few words the following question: If the Gulf Stream is considered to be not a voluminous deep-water course of the ocean, but only a drift current, or, in other words, a shallow, thin surface current caused by and dependent on the winds, what would then necessarily be its condition?

Those who assume the Gulf Stream to be merely a drift current cannot possibly have well taken into consideration the system of winds prevailing between Newfoundland and Spitzbergen, in the sea north of the latter to 82° N. and at Nova Zembla. The supposition, that southwesterly winds prevail in the North Atlantic Ocean between the 30th and the 60th parallels of latitude, may suffice for a rough generalization of the winds in toto, but surely not for their relation to the Gulf Stream. If considered the propelling power of so wonderful a water-course from the equatorial ocean to 82° N. latitude, they vary in the different seasons, and even in one and the same season, so extraordinarily that the Gulf Stream would be compelled to take other directions in summer than in winter, and again at one and the same time to run at one place to the northeast, at another to the southwest, at a third to the east, at a fourth to the southeast, and so forth. The best representation of the winds of the North Atlantic Ocean to latitude 50° N, in the four seasons, is to be found in the charts published by the British Board of Trade;[161] a single glance at these will be sufficient to show that the Gulf Stream, even to the south of latitude 50 N., requires other motors beside the winds. There might be, however, after all, a drift stream possibly carried with the wind up to latitude 50° or 60° N.

But to the north of the parallel of latitude 60° N. northerly winds are the prevailing ones, blowing directly in the face of the course of the Gulf Stream. Considering but the relatively limited region between Newfoundland and Iceland, we find the winds to prevail in January: at Newfoundland from the northwest, in Greenland from the east, while at Iceland they blow in nearly equal proportions from all directions.[162]

On the Norwegian coast, according to Mohn, the wind at Vardöe is generally from the southwest, but in July from the southeast; in Andenes mostly from the south, in July from the west; in Villa southeast, in July southwest; in Aalesund southwest, in July west; in Bergen mostly south, but in July north; in Lister northwest, in January east; in Lindesnes west, in January northwest.[163]

The most important treatise on the winds of the globe is that lately published by Alexander Buchan;[164] it contains twelve charts, one for each month of the year, the study of which I recommend. Buchan describes the prevailing winds between Norway, Scotland, and Iceland as follows: In all Scotland and toward the west, at least to the Faroe Islands, the winds in winter are from the southwest, but very few from the east or northeast. In Iceland, however, the mean direction of the wind is east-northeast; on the west coast of Norway the prevailing direction in the winter is southeast, or south-southeast, or, in other words, the wind blows from the land, where the temperature is extremely low at that time. In the summer the winds in Iceland are easterly, with some northing in them; in Scotland the western are prevailing, and in Norway they blow in the opposite direction of those in winter.[165]

If the warm North Atlantic Current depended entirely upon the winds, how different and how irregular would it then be necessarily at the various places and in the various seasons of the year! The Gulf Stream is much more regular, more constant, and more powerful than all the various winds throughout its course. A glance only at the sea-temperature stations, marked on the accompanying charts in red color, must refute the theory of a drift current; if, for instance, Iceland should receive its high temperature in winter through winds or a drift current, they must come directly from the south, but in that case they could not at the same time be the cause of the temperate weather of Norway, &c.

The Gulf Stream withstands the influence of the coldest winter and winds. Striking cases are offered by the observations of Dr. Hayes in Smith's Sound, while he wintered at Port Foulke. During the most severe weather, with the thermometer below the freezing point of mercury, once even at —70°, the sea in the vicinity, a branch of the Gulf Stream, was always open, so that the beating of the waves against the shore and against each other could always be heard, also when the sun did not appear for months, and the sea could not be seen.[166] But the warmest portion of the Gulf Stream has, on the contrary, not the least influence upon the temperature of the United States, although running very close to its coast, not only because its direction is *from* the coast and the cold Labrador Stream running south intervenes between it and the coast, but also because the prevailing winds prevent the influence. Boston, for instance, situated in latitude 42½° N., only about 320 miles from the hot (77°) tongue of the Gulf Stream, has a mean temperature in January of 27°, while Havö, in latitude 71¼° N., near the North Cape, distant by air line at least 3,450 miles from the same tongue, still has 29°.5.

Winds tempered by the Gulf Stream and then blowing over distant cold regions, have sometimes an astonishing influence, as, for instance, at Omenak, in Northern Greenland, latitude 70½° N., where the east-southeast winds coming from the Gulf Stream, although they have to cross first the extensive glaciers of Greenland, possess, when arriving, still so high a temperature that in

January and February they cause a rise of the thermometer of 34° above the monthly mean, (which is for January —6°.2.) Hence the unsteadiness of the climate in that region, and the very great fluctuations in the annual means, as, for instance:

December 1831, +17°.6; January 1820, +20°.8; March 1840, +18°.7.

December 1832, —18°.8; January 1835, —16°.0; March 1832, —16°.8.[167]

After the foregoing had been written and set in type I received, through the kindness of Professor Thomson, of Belfast, memoranda, charts, and profiles in manuscript of the results of the British Sounding Expedition in the North Atlantic Ocean, between the Faroe Islands and Spain. In view of the great importance of these results I deem it proper to add here the following table of the thermometric observations of the expedition, at the surface of the sea and at various depths to 2,435 fathoms:

Thermometric observations by the expedition in her Britannic Majesty's ship Porcupine in the North Atlantic Ocean, between the parallels of latitude 47° 38′ and 62° 01′, at depths to 14,610 feet, from May 31 to September 7, 1869.[168]

Date.	Position.		Temperature of surface.	Deep-sea temperature.		Date.	Position.		Temperature of surface.	Deep-sea temperature.	
	Latitude N.	Longitude from Greenwich.		Depth in fathoms.	Temperature.		Latitude N.	Longitude from Greenwich.		Depth in fathoms.	Temperature.
	° ′ ″	° ′ ″					° ′ ″	° ′ ″			
May 31	51 51 00	11 50 00 W.	54.0	370	48.9	July 30	51 01 00	11 21 00 W.	60.6	458	48.2
June 1	51 22 00	12 25 30 W.	54.0	808	41.4	Aug. 16	59 23 00	7 04 00 W.	53.8	374	46.0
June 1	51 38 04	12 50 32 W.	54.5	723	43.0	Aug. 16	59 34 00	7 18 00 W.	54.0	542	43.7
June 2	51 56 28	13 39 40 W.	53.4	251	49.5	Aug. 17	59 43 00	7 40 00 W.	53.6	475	45.5
June 2	52 07 04	12 52 08 W.	54.0	364	48.9	Aug. 17	59 54 00	7 52 00 W.	52.5	355	46.2
June 3	52 25 20	11 40 30 W.	54.0	90	50.0	Aug. 18	60 06 00	8 14 00 W.	51.6	440	41.9
June 4	52 14 00	11 48 00 W.	53.1	159	50.5	Aug. 18	60 25 00	8 10 00 W.	52.0	384	30.6
June 10	53 15 30	11 51 00 W.	54.0	106	51.1	Aug. 18	60 25 00	7 26 00 W.	52.0	490	30.0
June 11	53 16 25	12 42 00 W.	53.4	165	49.8	Aug. 19	59 56 00	6 27 00 W.	52.5	363	31.5
June 11	53 23 00	13 29 00 W.	54.5	85	49.6	Aug. 19	60 04 00	6 19 00 W.	52.5	605	29.8
June 14	53 41 00	14 17 00 W.	52.3	670	42.6	Aug. 19	60 02 00	6 11 00 W.	52.5	480	30.9
June 14	53 42 00	13 55 00 W.	53.6	208	49.6	Aug. 19	60 14 00	6 17 00 W.	52.0	632	30.6
June 15	53 48 45	13 15 30 W.	53.1	173	49.6	Aug. 20	60 21 00	6 51 00 W.	51.4	540	30.9
June 16	54 05 00	12 17 00 W.	52.3	422	47.1	Aug. 20	60 21 00	5 41 00 W.	52.7	580	29.8
June 16	54 18 50	11 49 50 W.	52.9	816	39.4	Aug. 21	61 03 00	5 58 00 W.	49.5	167	44.4
June 17	54 32 10	11 44 40 W.	52.7	1,425	40.6	Aug. 24	62 01 00	5 19 00 W.	50.2	114	44.8
June 17	54 28 45	11 44 00 W.	52.7	1,230	37.8	Aug. 24	61 59 00	4 38 00 W.	49.6	125	44.6
June 18	54 15 00	11 09 00 W.	53.1	183	49.3	Aug. 24	61 57 00	4 02 00 W.	48.9	317	30.4
June 28	54 53 30	10 56 00 W.	54.5	1,360	37.4	Aug. 25	61 21 00	3 44 00 W.	49.6	640	30.0
June 29	55 11 00	11 31 00 W.	55.4	1,443	36.7	Aug. 26	61 10 00	2 21 00 W.	52.0	345	30.0
June 30	55 40 00	12 46 00 W.	56.1	1,476	36.5	Aug. 26	61 15 00	1 44 00 W.	52.5	267	45.7
July 1	56 08 00	13 34 00 W.	57.0	1,263	37.2	Aug. 27	60 32 00	0 29 00 W.	51.8	64	49.1

Thermometric observations, &c.—Continued.

Date.	Position.		Temperature of surface.	Deep-sea temperature.		Date.	Position.		Temperature of surface.	Deep-sea temperature.	
	Latitude N.	Longitude from Greenwich.		Depth in fathoms.	Depth in fathoms.		Latitude N.	Longitude from Greenwich.		Depth in fathoms.	Temperature.
	° ′ ″	° ′ ″					° ′ ″	° ′ ″			
July 1	56 07 00	14 19 00 W.	57.2	630	43.5	Aug. 27	60 23 00	0 33 00 E.	52.5	75	43.9
July 2	56 13 00	14 18 00 W.	57.0	420	46.4	Aug. 27	60 01 00	0 18 00 E.	53.4	67	43.7
July 2	56 26 00	14 28 00 W.	57.6	109	46.4	Aug. 28	60 04 00	0 21 00 W.	53.4	66	45.0
July 3	56 41 00	13 39 00 W.	56.8	164	46.4	Sept. 1	60 17 00	2 53 00 W.	52.9	103	48.6
July 3	56 58 00	13 17 00 W.	57.4	345	46.6	Sept. 1	60 20 00	3 05 00 W.	52.3	76	48.9
July 3	57 30 00	13 30 00 W.	55.6	54	48.2	Sept. 1	60 29 00	3 06 00 W.	52.7	84	48.9
July 5	56 44 00	12 52 00 W.	57.6	1,215	37.0	Sept. 1	60 39 00	3 09 00 W.	52.5	203	47.7
July 5	56 34 00	12 22 00 W.	56.7	1,264	36.7	Sept. 1	60 45 00	3 06 00 W.	51.4	250	41.9
July 6	56 24 00	11 49 00 W.	55.9	1,380	37.0	Sept. 2	60 36 00	3 58 00 W.	50.2	344	29.8
July 6	56 15 00	11 25 00 W.	56.7	1,360	37.2	Sept. 2	60 34 00	4 40 00 W.	50.9	560	29.8
July 7	56 05 00	10 23 00 W.	55.9	1,320	37.4	Sept. 2	60 14 00	4 30 00 W.	52.0	290	41.4
July 20	50 38 30	9 27 00 W.	64.2	74	49.6	Sept. 3	59 44 00	4 44 00 W.	52.0	76	48.9
July 20	49 51 30	10 12 00 W.	66.0	75	49.6	Sept. 3	59 49 00	4 42 00 W.	53.1	92	49.3
July 21	49 07 00	10 57 00 W.	63.3	96	51.1	Sept. 3	59 54 00	5 01 00 W.	53.1	142	49.1
July 21	48 50 00	11 09 00 W.	64.0	725	43.9	Sept. 3	60 00 00	5 13 00 W.	52.3	312	41.2
July 22	47 38 00	12 08 00 W.	65.5	2,435	36.5	Sept. 3	60 06 00	5 08 00 W.	53.1	362	37.4
July 24	47 39 00	11 33 00 W.	64.2	2,090	36.3	Sept. 4	59 34 00	6 34 00 W.	54.3	155	49.1
July 26	49 01 30	11 56 30 W.	63.0	557	46.8	Sept. 4	59 40 00	6 34 00 W.	53.8	190	48.7
July 26	49 01 30	12 05 00 W.	63.3	517	47.7	Sept. 4	59 48 00	5 31 00 W.	53.6	445	30.2
July 26	49 04 00	12 22 00 W.	63.3	584	46.4	Sept. 6	59 35 00	9 11 00 W.	52.5	767	41.5
July 27	49 12 00	12 52 00 W.	62.6	862	39.6	Sept. 6	59 26 00	8 23 00 W.	53.4	705	42.6
July 28	50 01 00	12 26 00 W.	61.7	1,207	37.6	Sept. 7	59 38 00	7 46 00 W.	53.1	445	45.5
July 29	50 20 00	11 34 00 W.	61.3	865	39.4	Sept. 7	59 41 00	7 34 00 W.	53.1	458	45.1

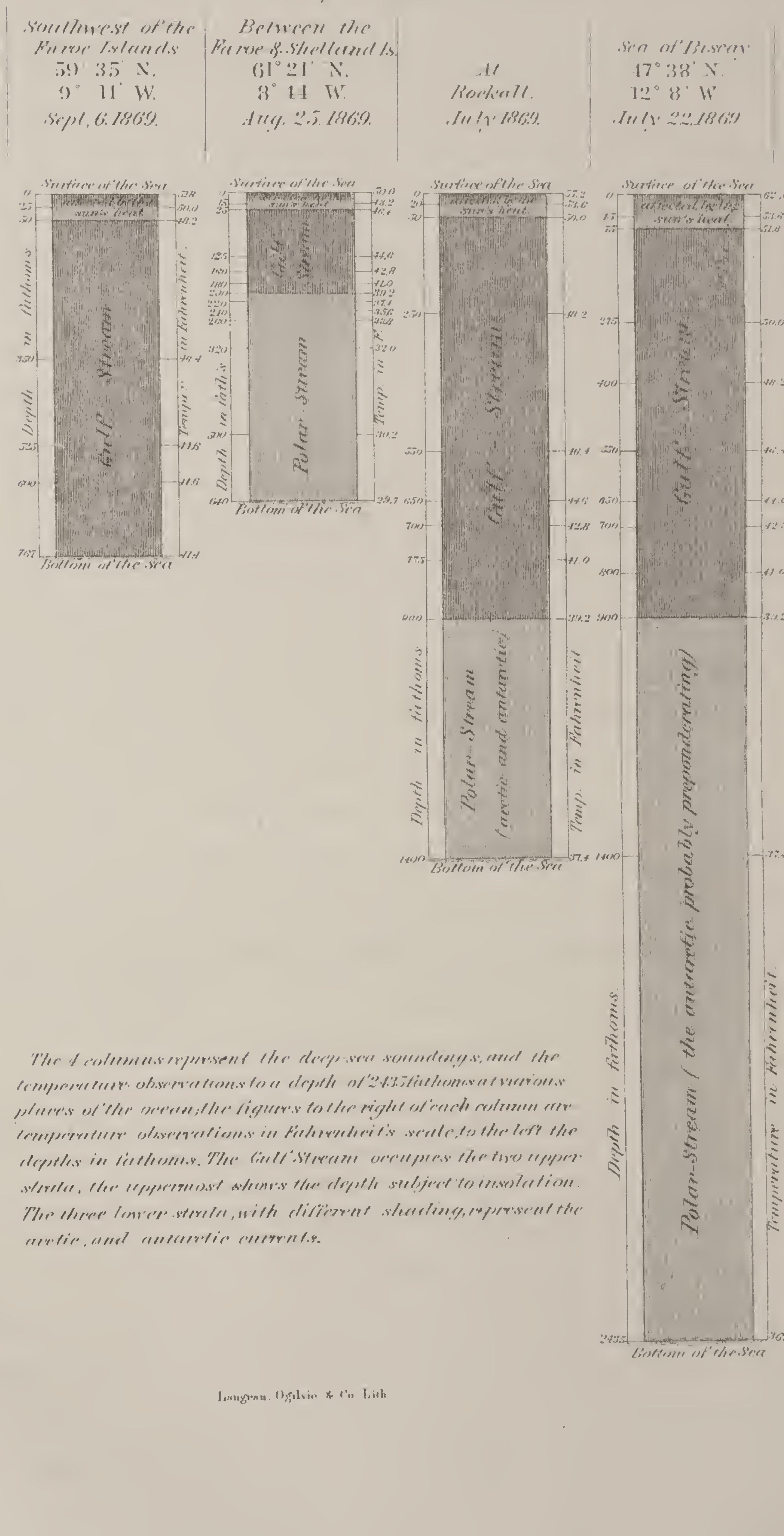
These temperatures of the surface of the sea agree well with the results of my Chart No. 1. The researches of this expedition are, in regard to the currents and the temperature of the North Atlantic Ocean at various depths, the most important of all carried out thus far. Their result is represented in the four profiles on the accompanying plate; it is, indeed, unexpected and wonderful. The reports published previously were but preliminary; the memoranda communicated to me now are new, and constitute the final result of all the material collected and discussed.

This final result is, in a high degree, a confirmation of my opinion, which I expressed five years ago, and have repeated again in the first lines of this memoir, that the Gulf Stream reaches to Europe and farther, and that it constitutes a deep and voluminous stream, not a surface drift, weak and dependent upon the winds.

The English explorers prove undeniably that the Gulf Stream has, between

Sections

representing the observations of the temperature- and current relations in the North Atlantic Ocean, from 47° 38' to 61° 21' north lat. by the Expedition in H. M. Ship "Porcupine" July to September 1869.[162]



The 4 columns represent the deep-sea soundings, and the temperature observations to a depth of 2435 fathoms at various places of the ocean; the figures to the right of each column are temperature observations in Fahrenheit's scale, to the left the depths in fathoms. The Gulf Stream occupies the two upper strata, the uppermost shows the depth subject to insolation. The three lower strata, with different shading, represent the arctic, and antarctic currents.

Laugesen, Ogilvie & Co. Lith.

Ireland and Spain, still a depth of 900 fathoms, and equally as much near the Rockall Rock, west of the Hebrides. Between Rockall and the Faroe Islands, near the parallel of latitude 60° N., it reaches to the bottom of the sea, which has a depth there of 767 fathoms, and at that depth the Gulf Stream has still a temperature of 41°.5.

It would require truly a strong wind to cause currents of 900 and 767 fathoms in depth!

Between the Faroe and the Shetland Islands, where my Chart No. 1 shows already the influence of a polar current from Jan-Mayen into the German Sea the Gulf Stream is but 200 fathoms deep, a third of the entire depth of the ocean in that region, still an immense stratum, notwithstanding the quantitative preponderance of the Polar Stream.

Very interesting are also the results of the observations of the insolation, the influence of the sun on the upper stratum of the sea. It was traceable in latitude 61° 21′ N., on the 25th of August, to a depth of 25 fathoms; in latitude 59° 35′ N., on the 6th of September, to 50 fathoms; at Rockall, in July, also 50 fathoms, and in the Sea of Biscay (47° 38′ N.) to 75 fathoms.

But the most wonderful is that the English savants have found weighty reasons to assume the existence of an *antarctic* current directly over the bottom of the sea, clear up to the Irish and Scottish coasts, meeting there an arctic stream.[170] In the notes of Professor Thomson,[171] now before me, the stratum at Rockall, from 900 to 1,400 fathoms below the surface, is designated as "Cold indraught, arctic and antarctic," (temperature 39°.2 to 37°.4,) and the stratum between 900 and 2,435 fathoms between Ireland and Spain as, "Indraught of cold water, probably mainly antartic, falling in by gravitation principally," (temperature, 39°.2 to 36°.5.)

7.—THE SALT OF THE OCEAN AND ITS RELATION TO THE GULF STREAM—BOTTLE EXPERIMENTS.

The salt of the ocean is an excellent medium for inquiry into the currents of the same. The greater the evaporation, (as in the seas of the torrid zone,) the greater is the proportion of salt in the ocean; the smaller the evaporation, (as in the polar seas,) the less salt is contained in the sea. Seas with great evaporation, but without sweet water tributaries, as, for instance, the Red Sea, contain more salt than those into which sweet waters empty; and the proportion of salt grows less in the seas of the temperate and frigid zones, which have a permanent influx of sweet water through rivers and glaciers. A swimming iceberg, moving from higher into lower latitudes and melting more and more, lessens perceptibly the saltness of the sea surrounding it.

The Mediterranean Sea, which is exposed to the hot and dry winds of Africa, promoting evaporation, contains a greater proportion of salt than the great ocean in general, viz., $\frac{38}{1000}$, (exactly 37.396,) or nearly one twenty-sixth; that is, in 1,000, or 26 parts of water respectively 38 or 1 equal parts of salt. The mean saltness of the North and South Atlantic Ocean, between the South Cape of Greenland and Cape Horn, is 35.8; that of the Indian Ocean, between Africa and the East Indies, 33.8; of the great ocean between the East Indies and the Aleutian chain, 33.6, and between the Aleutian groups and the Society Islands, 35.2.

The saltness of the German Sea is, in the mean, 32.8; of the Kattegat and the Sound, 16.2; of the Baltic Sea, only 4.9; of the Black Sea, 15.9.

The Red Sea has (according to the analytical examinations to date) the absolutely greatest proportion of salt, viz., 43.067, or one twenty-third; and the harbor of Cronstadt, in the Bay of Finland, the absolutely smallest, viz., 0.610, or $\frac{1}{1639}$.

George Forchhammer, Professor of the University and Director of the Polytechnical Institute at Copenhagen, published,[172] in 1865, a voluminous treatise on the nature of the sea-water in all parts of the world, based upon researches for twenty years, the results of which for the North Atlantic Ocean and its bays, north of the 30th degree of latitude, are exhibited in the following table, arranged according to the proportion of salt:

Proportion of salt (number of parts of salt in 1,000 parts of sea-water) in the Gulf Stream and the adjoining regions of the North Atlantic Ocean, between 30° and 80° N. latitude. By Professor George Forchhammer.

I.—From 37.0 to 34.0 parts of Salt to 1,000 parts of Sea-water.

Locality.	Position. Latitude N.	Position. Longitude from Greenwich.	Parts of salt.	Observer and date.
	° ′	° ′		
North Atlantic Ocean	38 18	43 02 W.	36.9	Ornen, November 9, 1846.
Do do	32 52	68 W.	36.6	Von Dockum, August 3, 1843.
Do do	37 05	48 24 W.	36.6	Ornen, November 7, 1846.
Do do	31 51	67 23 W.	36.5	Von Dockum, August 3, 1843.
Do do	55 45	20 30 W.	36.5	Unknown.
Straits of Gibraltar	....	....	36.4	Schulz, September 28, 1860.
North Atlantic Ocean	40 21	54 15 W.	36.4	Von Dockum, August 13, 1843.
Do do	40 53	36 23 W.	36.4	Ornen, November 11, 1846.
Do do	36 13	55 7 W.	36.3	Ornen, November 5, 1846.
Do do	39 39	55 16 W.	36.3	Von Dockum, August 13, 1843.
West of Spitzbergen	76 15	13 15 E.	36.3	Nordenskiöld and Blomstrand.
North Atlantic Ocean	37 24	61 8 W.	36.1	Von Dockum, August 7, 1843.
Do do	47 10	18 45 W.	36.1	Ornen.
Do do	47 18	21 6 W.	36.1	Von Dockum.
Do do	48 10	9 35 W.	36.1	Ornen.
Do do	44 39	30 20 W.	36.0	Ornen, November 13, 1846.
Do do	46 22	22 55 W.	36.0	Ornen, November 15, 1846.
Do do	36 52	66 38 W.	35.9	Von Dockum, August 6, 1843.
Do do	47 17	14 24 W.	35.9	Ornen.
Do do	47 40	32 7 W.	35.9	Von Dockum.
Do do	47 45	9 30 W.	35.9	Schulz.
Do do	47 17	19 9 W.	35.6	Von Dockum.
Do do	47 50	33 50 W.	35.6	Von Dockum.
Do do	50 3	11 6 W.	35.6	Von Dockum.
Do do	51 9	12 11 W.	35.6	Porcupine.*
Do do	55 32	13 59 W.		
Do do	59 50	7 52 W.	35.6	Gram, May 5, 1845.
Do do	64 30	26 24 W.	35.6	Schaffner, September 3, 1860.
Do do	60 9	14 7 W.	35.5	Gram, May 7, 1845.
Do do	64 15	27 8 W.	35.5	Schaffner, September 6, 1860.
Do do	60 20	7 20 W.	35.4	Gram, 1845.
Do do	59 50	26 23 W.	35.4	Gram, May 15, 1845.
Do do	60 30	26 37 W.	35.4	Gram.
Do do	64 16	24 1 W.	35.4	Schaffner, September 2, 1860.
Do do	63 25	29 36 W.	35.4	Schaffner, September 8, 1860.

* Between the two positions.

Proportion of salt in the Gulf Stream, &c.—Continued.

Locality.	Position. Latitude N.	Position. Longitude from Greenwich.	Parts of salt.	Observer and date.
	° ′	° ′		
North Atlantic Ocean	63 34	27 35 W.	35.4	Schaffner, September 9, 1860.
Do do	60 23	33 32 W.	35.4	Gram, May 18, 1845.
Do do	61	16 32 W.	35.3	Gram, 1845.
Do do	59 58	20 30 W.	35.3	Gram, May 10, 1845.
Do do	62 15	23 3 W.	35.3	Paludan, May 10, 1845.
East coast of Greenland	62 47	37 31 W.	35.3	Schaffner, September 10, 1860.
Do do	62 17	38 18 W.	35.3	Schaffner, September 11, 1860.
North Atlantic Ocean	60 9	5 19 W.	35.2	Paludan, May 8, 1845.
Do do	63 24	33 23 W.	35.2	Schaffner, September 9, 1860.
Do do	59 26	39 4 W.	35.1	Gram, May 20, 1845.
Do do	58 58	36 W.	35.0	Gram, September 1, 1845.
Do do	57 57	46 1 W.	35.0	Gram, May 22, 1845.
North of the Straits of Dover			35.0	Von Dockum, September 16, 1845.
North Atlantic Ocean	60 25	3 15 W.	34.8	Skibsted, 1844.
East coast of Greenland	59 49	40 56 W.	34.7	Schaffner, September 14, 1860.
Davis' Straits	60 32	53 11 W.	34.4	Gram, May 26, 1845.
On the coast of Norway	70 30	19 5 W.	34.4	Nordenskiöld and Blomstrand.
Between the Orkneys and Norway.			34.3	1844.
North Atlantic Ocean	44 33	42 34 W.	34.1	Von Dockum, August 18, 1843.
2.—FROM 34.0 TO 30.0 PARTS OF SALT TO 1,000 PARTS OF SEA-WATER.				
North Atlantic Ocean	43 26	44 19 W.	33.9	Von Dockum, August 17, 1843.
North of Spitzbergen	80	12 E.	33.6	Blomstrand.
Twenty-four miles west of Disco.	69 45		33.6	Rink, July 5, 1849.
Eight miles from Godhavn, Disco.	69 50		33.4	Kaiser, September 3, 1845.
Southwest of Egersund, Norway			33.3	1844.
West coast of Greenland	60		33.2	Gram, June 12, 1845.
Do do	68 43	52 45 E.	33.2	Kaiser, August 30, 1845.
Do do	62 8		33.1	Gram, June 2, 1845.
Do do	64 41		32.9	Kaiser, September 5, 1845.
German Sea, Skager Rack			32.7	Von Dockum, September 18, 1845.
West coast of Greenland	66 58		32.3	Kaiser, September 4, 1845.
German Sea			31.1	Von Dockum, September 18, 1845.
East coast of Greenland	60 49	41 45 W.	30.5	Schaffner, September 30, 1860.
German Sea			30.5	Back.

Proportion of salt in the Gulf Stream, &c.—Continued.

3.—FROM 30. 0 TO 10. 0 PARTS OF SALT TO 1,000 PARTS OF SEA-WATER.

Locality.	Position.		Parts of salt.	Observer and date.
	Latitude N.	Longitude from Greenwich.		
	° ′	° ′		
Sound			23. 2	April 17 to September 11, 1846.
Cattegat			19. 9	Skibsted, 1844.
Cattegat, north of Anholt			17. 4	June, 1845.
Cattegat, north of Cullen			17. 3	June, 1845.
Copenhagen			15. 8	March 3 to April 21, 1852.
Sandefiord, southeast coast of Norway.			14. 0	Strecker.
Cattegat, north of Cullen			11. 3	April, 1845.
Copenhagen			10. 9	October 4, 1846.
4.—FROM 10. 0 TO 0. 6 PARTS OF SALT TO 1,000 PARTS OF SEA-WATER.				
Between Bornholm and Sweden.			7. 5	Bellona.
Between Aland and Gothland			7. 3	Bellona.
Baltic, northeast of Gothland	58 27	20 E.	7. 1	Bellona.
Gulf of Finland			6. 9	Bellona.
Svartklubben, north of Stockholm.			5. 9	
Gulf of Finland			4. 8	Bellona.
Gulf of Finland			3. 6	Bellona.
Gulf of Finland, west of Cronstadt.			0. 7	Bellona.
Commercial harbor of Cronstadt			0. 6	Bellona.
5.—MEDITERRANEAN SEA.				
Between Candia and Africa	33 34	24 34 E.	39. 3	Schulz, October 28, 1860.
Between Sardinia and Naples	40 25	11 43 E.	38. 7	Schulz, October 20, 1860.
East of Malta	36 10	16 10 E.	38. 5	Schulz, November 13, 1860.
South of Barcelona	41 12	2 23 E.	38. 3	Schulz, October 10, 1860.
Between Barcelona and Corsica.	42 25	6 E.	38. 3	Schulz, October 12, 1860.
Between the Balearic Isles and Spain.	40 28	1 48 E.	38. 1	Schulz, October 8, 1860.
Between Malta and Greece	37 20	16 32 E.	38. 0	Schulz, October 23, 1860.
Position unknown			37. 7	From the Analyses Chimiques.
Malta			37. 2	Ennis, 1837.
East of Gibraltar	36 09	4 02 W.	37. 0	Schulz, September 29, 1860.
Straits of Gibraltar			36. 4	Schulz, September 28, 1860.

Proportion of salt in the Gulf Stream, &c.—Continued.

6—Black Sea.

Locality.	Position.		Parts of salt.	Observer and date.
	Latitude N.	Longitude from Greenwich.		
	° ′	° ′		
Fifty English miles from the Bosphorus.	....	....	18.1	
Black Sea..................	....	....	17.7	Göbel.
Azov Sea..................	....	....	11.9	Göbel.

From these data I have constructed a saltness chart of the Gulf Stream and of the North Atlantic Ocean, with curves of equal saltness, which agree surprisingly with the results of the accompanying Charts No. 1 and No. 2. I am sorry that the space allotted to this memoir in the "Geographische Mittheilungen" does not permit at present the publication of this chart.

The greatest saltness of the ocean (36.928) is to be found at the vertex of the Gulf Stream, in latitude 38° 18′ N., longitude 43° 02′ W. of Greenwich, close to the July curve of 77 (20 Réaumur) temperature on the accompanying Chart No. 1; there is only one spot, from that place to the Equator, of a higher proportion. The salt curve (36.0) trends high to the north in the direction of Iceland, the Hebrides, and the British Channel, but the sea between Scotland and Iceland loses in saltness, averaging on and north of the parallel of latitude 60° only 35.4, and in one place, west of the Shetland Islands, it is even only 35.2, from observations made principally in May. North of the Shetland Islands we have but three observations: one close to the coast of Norway north of Tromsöe: the second west of the southern cape of Spitzbergen near the July isothermal curve of 41°, (4° Réaumur;) and the third north of Spitzbergen in latitude 80° N.

That the saltness of the sea between Scotland and Iceland lessens in May to 35.2, agrees entirely with the fact that about this time a branch of the Polar Stream descends into this region and presses the Gulf Stream to the south and the east. Really wonderful is the agreement of the two charts west of the south cape of Spitzbergen, where the one (No. 1) shows the Gulf Stream risen again to the surface, and the saltness chart in latitude 76° 15′ N., longitude 13° 15′ E. of Greenwich, according to the analyses of Nordenskiöld and Blomstrand of the Swedish expedition, a saltness of the sea of not less than 36.254. North of Spitzbergen, in latitude 80° N., longitude 12 E. of Greenwich, it decreases again to 33.623; but if it is considered that the saltness of the eastern parts of the German Sea is only 30.0, that proportion (33.62) in the Arctic north of Spitzbergen is still a very great one, and testifies most strongly to the extension of an arm of the Gulf Stream as far as this latitude.

Professor Forchhammer obtained through Colonel Schaffner and Captain Gram comparatively quite numerous specimens of water from the sea between Iceland and East Greenland, the analysis of which gave the unexpectedly high proportion of 35.6, to explain which he ventured repeatedly the opinion that the East Greenland Current (so called by him) cannot be a polar stream, but is in reality the Gulf Stream "returning from the north along the east coast of Greenland."[173] That it is not a polar stream is true, but it is by no means a branch of the Gulf Stream returning from the north; on the contrary, it is the Gulf Stream itself coming directly from the south, which, as we have seen, causes not only the high temperature of the west coast of Iceland in winter and summer, but even presses back the Polar Stream from the north coast of Iceland.

The analyses of Dr. Forchhammer corroborate in a high degree the fact, deduced from the temperature observations, that the Gulf Stream reaches quite close to the southeastern coast of Greenland and compresses there the Polar Stream, coming from the north, into a minimum of width on the surface; within its reach the saltness lessens to 30.5, but only to about twenty miles from the coast; east of that distance the saltness increases rapidly.

The saltness observations agree furthermore excellently with the Labrador Stream cutting into the Gulf Stream. Mistaking the system of currents, Dr. Forchhammer ascribes the low saltness there to the St. Lawrence River, although it empties into the ocean at a distance of about nine hundred miles from this region, and is, besides, carried by the cold North American coast current to the southwest, so that its waters cannot reach so far east.

Of great interest also are Dr. Forchhammer's researches in regard to the surface and deep-sea currents of the Cattegat and the Sound,[174] which, together with Lord Dufferin's temperature observations in the same region in 1856, throw new light on the surface and sub-surface branches of the Gulf Stream, as well as of the Polar Stream, as far as into the German Sea.

But one of the most important facts for the knowledge of the Gulf Stream, established by the inquiries into the saltness of the ocean, is the relatively great proportion of salt found in the southeastern parts of Davis' Strait and Baffin's Bay. The temperature observations, especially of the Montreal Steamship Company, have shown us (Chart No. 1) that the Gulf Stream, immediately after arriving at Newfoundland, turns in a sharp bend and proceeds to the north and northwest, leaving to the Polar Stream but a relatively narrow bed, which is fully confirmed by the salt chart; the saltness there in latitude 43° 26′ N., longitude 44° 19′ W. of Greenwich, is but 33.9, and this low figure is distant only 300 nautical miles from the high proportion 36.9.

As the current charts of Maury, Findlay, Beechey, and others do not show the currents correctly even in this region, the desire is surely justified that so valuable data for the better knowledge of the currents, as the researches into the nature of the sea-water furnish, should be obtained in a greater extent also for those parts of the ocean where there are yet but few observations, as, for instance, in the German Sea; and as specimens of sea-water can be obtained so readily, it may well be expected that this branch of physical research will hereafter find more attention.

There have also until lately less reliable means been employed to ascertain and establish the system of currents, as, for instance, the bottle experiments, since the beginning of this century. Admiral Irminger (in the annexed memoir) remarks in regard to them very correctly as follows:

> These experiments result frequently in very unreliable arguments for the direction of the currents, because the bottles used for the purpose are generally so light that they are propelled as much by the wind as by the current. If there are bottles to be used for ascertaining the direction of currents, they must, in order to escape the influence of the wind, be made expressly so thick and heavy that but little of the bottle can remain above the surface of the sea.

But still more precarious is, in my opinion, the manner in which the results of the experiments in most cases were made use of. Marking on the chart the places where the bottle had been dropped overboard and where it had been fished up again, a straight line was drawn between the two, and this generally accepted as the approximate course made good by the bottle.

In this way there will be found not only on the bottle charts published by Daussy and Becher since 1840, but already on Rennell's chart of 1832, a number of bottle courses in the North Atlantic Ocean, all of which are from west to east, some from the vicinity of Cape Farewell and Davis' Strait across the ocean to Ireland.[175] They can still be seen on the current chart of the Atlantic Ocean in the Physical Atlas of Professor Berghaus.[176] Surely not one of these bottles has traveled the way thus laid down; they have been propelled first with the Labrador Stream southeast until the same meets the Gulf Stream, and then with the latter to the northeast. The course of the bottles from Baffin's Bay directly to Europe, as laid down, is exactly the reverse of the true current, and it is evident that the bottle experiments are the main cause of the erroneous representation, up to our days, of the currents between Labrador and the British Isles, as, for instance, in Maury's and Findlay's[177] charts, &c.

Immediately after Captain Becher had published, in 1843, his first "bottle chart,"[178] protests against it, and especially against the irrational way of being made use of, were published by eminent men, as, for instance, Sir John Ross, who designated it directly a "bottle fallacy," fortifying his opinions with very weighty reasons and with many cases of his experience.[179] A long, at times angry, controversy followed; but now it appears to be pretty generally accepted that the bottle experiments are of no great value scientifically, and that they must be made use of with precaution and under the guidance of the general system of currents.

For some time they have been decidedly out of fashion, but many current charts, even of late edition, suffer yet from the results of erroneously interpreted bottle experiments.

8.—THE GULF STREAM BETWEEN THE PARALLELS OF LATITUDE 33° N. AND 82½° N.—RECAPITULATION.

After having traced, on the preceding pages, the Gulf Stream from its hot sources to the Arctic to within 7⅔ degrees of the North Pole, demonstrating and establishing it by figures and facts, I shall now review briefly the entire phenomenon, which in its influences may well be termed the mainstay of the culture of Europe and of the world.

1. The hot source and core of the Gulf Stream extends from the Straits of Florida along the North American coast, at all times, day and night, in win-

ter as in summer, even in January, with a temperature of 77° and more, up to the 37th degree of northern latitude, while at the same time and in the same latitude in Africa (Tunis) the temperature of the air is but 53°.4. The Gulf Stream transports and develops still in this latitude a higher temperature than water and air possess in the Atlantic Ocean even under the Equator, on which, neither in July nor in January, the temperature is ever as high as that of the Gulf Stream in latitude 37° N.

2. Under the 37th and the 38th degree of northern latitude the hot core of the Gulf Stream turns away from the American coast toward the east, beyond the meridian of Newfoundland and its banks to 40° longitude W. of Greenwich, where it still possesses a temperature in July of about 75°, and in January of about 66°. From there it proceeds to the northeast, diffuses nearly across the entire Atlantic, and surrounds the whole of Europe, to the Arctic and the White Sea of Archangel, with a broad and permanent warm-water course, without which England and Germany would be a second Labrador, and Scandinavia and Russia a second Greenland, buried beneath glaciers. Where, as in Fruholm, (71° 06′ N.,) the sun does not rise at all above the horizon during the entire month of January, in a latitude in which, in Asia and America, the mercury remains frozen for months; there the Gulf Stream preserves for the sea a temperature as high as 37.8. While the sun in the short days of winter sends forth his rays of light and warmth but for a few hours, and the influence of the latter is quickly lost again in the long nights, the Gulf Stream does not cease, day or night, to be the source of warmth.

The Gulf Stream carries, according to the computations of James Croll, as much heat to the north as 3,121,870 square miles (English) under the Equator receive from the sun; and this is computed further to be more than the total amount of heat which is carried by all the warm-air current from the entire periphery of the Equator toward the North Pole and toward the South Pole. The southwest winds receive their high temperature from the Gulf Stream; and only through the ocean, not by the winds, can warmth be carried into latitudes as high as those of the European coasts are.[180]

3. The Gulf Stream, as a whole, is as yet but little explored; we only know its influence in some degree. How limited our knowledge of it is may be inferred, for instance, from the fact that there are the most contradictory statements of its velocity and strength. A. G. Findlay, one of the principal

authorities on the Gulf Stream, computed (1869) its velocity as requiring one to two years to reach Europe from Florida, while, according to my computation, two months would suffice. There are many cogent supports for the latter, for instance the following: When General Sabine, in 1823, was at Hammerfest, barrels of palm-oil drifted on shore there belonging to a vessel which had been wrecked in the preceding year at Cape Lopez, on the African coast, in the vicinity of the Equator; comparing now the distance which these barrels have drifted with that from Florida to Europe, by the way of the Gulf Stream, the latter would require not one to two years, but only two months.

4. To conclude from the soundings, obtained so far, the Gulf Stream must be, up to the Arctic Ocean, a deep and voluminous water course; if it should not be so, the polar ice would reach also the European coasts. In the Antarctic Ocean the polar ice drifts all around the globe, as far at least as latitude 57° 5′ S., in many places to 50° and 40°, (latitudes corresponding respectively to those of the British Channel and the Mediterranean Sea;) on some even to 35°, (corresponding to the latitude of Morocco;) but not the smallest particle of northern polar ice has ever reached even the northernmost cape of Europe. The Gulf Stream, in its course, is more powerful and steady than all the winds; only the polar ice and the polar currents, in spring and summer, exercise a great influence over it. The Polar Stream presses at three places against it; first from the northwest, east of Newfoundland; then from the north, east of Iceland; at both these places the Polar Stream is buried and proceeds beneath the Gulf Stream, after having pushed it off laterally to the southeast. But for the third time, at Bear Island, the Polar Stream comes directly against the Gulf Stream, from the northeast, splits it into two or three branches, and in places even presses it beneath its own waters, at least in July. Under the lee of Spitzbergen this latter branch rises again and proceeds on the surface, according to Parry's observations,[181] to latitude $82\frac{1}{3}°$ N. The main branch, east of Bear Island, has been traced by Dr. Bessels to latitude 76° 08′ N., where in August 1869 it possessed still a temperature of 41°.2.

5. These three conflicts with the polar currents cause the summer (July) isothermal lines of the Gulf Stream to make deep cuts at the respective places, and to assume a certain concavity of form which will not be found in those of the winter, (January.) But even if the July curves, when compared with

those of January, appear pressed back somewhat to the south, they show, nevertheless, in the whole a very high temperature for the entire North Atlantic basin from Labrador and Greenland to Europe, Spitzbergen, and Nova Zembla. A great depression of the temperature of the surface is caused by the Polar Stream descending east of Iceland, and, after its collision with the Gulf Stream, proceeding beneath the latter, principally when reaching the shallow German Sea. It is evident that this branch of the Polar Stream, and the winds blowing from it, are depressing also the summer temperature of a considerable part of Western Germany. The temperature and the currents of the German Sea are, alas, a field still nearly entirely barren, but it is to be hoped that the German navy, German vessels and sailors, and German nautical societies and institutions, by delivering the ocean which washes the German shores from such a status, will yet participate a little in researches for which other nations in Europe and America have already done so much and deserved so well. It is pretty certain that a sub-surface polar current reaches, in summer, from Iceland and Jan-Mayen to the German coast, but there have been so far hardly any inquiries made about it. A remarkable confirmation of this supposed current is, for instance, the pumice stone (from Iceland or Jan-Mayen!) thrown on the North German coasts.[182]

6. In winter (January) the Gulf Stream is cut into much less. The pressure of the Polar Stream at Newfoundland is hardly visible on the chart, the curves being simply parallel with the coasts; east of Iceland a Polar Stream proceeding to the southeast cannot be inferred at all from the observations of the temperature of the sea at Iceland, the Faroe Islands, Scotland, and Norway, which bear toward each other quite different relations in January and in July. The relations in winter between Bear Island and Spitzbergen are yet unexplored, but we have known for a long time the grand effects of a relatively high-tempered sea up to Spitzbergen and Nova Zembla, even in the Taimyrland and Northeast Siberia. The polar streams, in conformity with the general laws of nature, are less powerful in the winter than in the summer; the polar ice does not drift as far southward; it makes fast, more or less, to the arctic coasts and islands; in spring and summer, on the contrary, it drifts along, similar to the glacier tongues in Alpine mountains, or the ice in our rivers. The Gulf Stream is in winter more powerful than in summer; while the polar streams, so to say, set at rest in some measure, withdraw their ice and concentrate it around the land. A striking proof of this is offered, for

instance, by W. C. Redfield's chart of the drift ice at Newfoundland, compiled from observations between 1832 and 1844.[183] Of one hundred cases of ice seen, eighty-seven occurred in April, May, June, and July; of the remaining thirteen there are seven in March, three in August, two in February, and one in January; none at all in September, October, November, and December, and from the 14th of August to March but three cases; therefore during the entire winter there is, so to say, no drift ice at all.

7. The relations of the temperature of the Gulf Stream, within themselves, are about the same in January as in July. In the latter month the isothermal curve of 6° Réaumur (45°.5 Fahrenheit) runs from Newfoundland far toward the north, beyond the whole of Europe; it corresponds in general with the January curve of 2° R., (36°.5 F.;) the amplitude of the Gulf Stream, therefore, that is, the fluctuation between its maximum and minimum temperature, (July and January, or August and February,) would be, on the average, only about 9°, (4° R.)

What immense contrast to this extraordinarily constant temperature is offered by the temperature of the air on the mainland! It may be seen at a glance in the entirely different directions of the isothermal lines for July and January on the accompanying charts. From the sea and air isothermal line of 2° R. (36°.5 F.,) at Philadelphia, to Northumberland Sound, with —40°, the distance is 2,280 miles, nearly due north. There is, therefore, in about each thirty miles a fall in temperature of one degree. From the same point at Philadelphia to the Gulf Stream east of Fruholm, on the same isothermal line of 2° R. (36°.5 F.,) there are in the direction of the Gulf Stream, in an air-line, about 5,400 miles, in which distance there is no fall at all in the temperature of the Gulf Stream: there, one degree fall in each thirty miles; here, the same temperature along 5,400 miles in a northeast direction. Such is the influence and the power of the Gulf Stream! In the latitude of Berlin, which has a mean temperature of the air in January of 28°, the Gulf Stream has 50 ; at the Faroe Islands, still 42°.1; but in Jakutsk, in the latitude of the Faroes, the air is 40° below zero, a difference of 82°.1.

To the Gulf Stream exclusively the facility is due with which it is possible to reach each year near Spitzbergen to latitude 80° N.; just by following its course the Norwegian fishermen come in open boats to within ten degrees of the North Pole, and Englishmen visit in light sailing vessels Spitzbergen, for pleasure and to hunt. In no other region of the world, in the high north or the high south, exist similar means to penetrate so far toward the Pole. The drift ice obstructs navigation, at an average, in the northern hemisphere twenty degrees of latitude; in the southern it is met thirty degrees nearer the equator.

But where in these high latitudes the branches of the Gulf Stream cooled down to about 39°.8, dive beneath the Polar Stream, there thickly packed ice may surely be expected at one and the same place and at all times. I deem it, therefore, advisable for polar expeditions to penetrate soon into the Polar Stream, the ice of which is not so thickly packed, but more diffused. The ice, which in the Polar Stream drifts to the south during the summer, does not return, and must leave behind places free of ice, which would easiest be reached within the Polar Stream. Hence the instructions to the German expeditions to make for the east coast of Greenland. When a simple fisher, Johannesen, succeeded in reaching, through waters considered to be very difficult, the east and the west coast of Nova Zembla everywhere, in latitudes 74 , 75°, 76°, and 76½°, then surely the same should be possible, with the aid of steam, in East Greenland, for a scientific expedition fitted out for the purpose.

Our knowledge of the globe, besides, will not be promoted greatly if expeditions always take the same old route, as, for instance, along the west coast of Spitzbergen, which has been followed innumerable times for the last three hundred years. There would be little prospect on such routes of discovering anything.

The exploration of the polar regions being urged now most strongly in all quarters, it may well be expected that, after exertions for three hundred years, they soon will be opened at last, and the physical geography of our globe materially completed. The great German expedition is now, I hope, fully at work, and Swedes, French, and Americans—nations who have done already much in this cause—are preparing for new exertions.

I have deemed it my duty, were it only on account of these new expeditions in prospect, to undertake the preparation of this memoir, incomplete as it may be, since it had to be built up anew from the foundation, and a great mass of unpublished data for the establishment and the proper representation of the currents of the North Atlantic Ocean had to be solicited and collected from distant sources. The knowledge of the temperature of the sea is, particularly in Europe, still in its infancy, and observations of value were made during the last years only by the Scottish and Norwegian institutions and societies; but there were many thousand isolated observations on the high seas which never had been brought yet in proper relation to each other.

It is most remarkable that, in treating a subject of the nature of that before us, even in our day, one authority should ignore another entirely, (I do not refer to shallow compilations,) or should not make use of previous observations in investigating its own. This, however, is really a fact: the Dutch treatises do not refer to the American examinations; Whitley ignores both; Irminger did not take notice of Dufferin, Inglefield, and many other eminent British authorities, and so forth. These sins of omission encouraged me to attempt a compilation which might better have been undertaken by more competent authority, a Dove, or a public institution established for the purpose.

I deemed my labors, which I consider but preliminary, highly rewarded, when I found how wonderfully the data, collected from so heterogeneous sources, did agree on the two charts constructed from them. A single observation, however, of the temperature of the sea is, on account of the ordinary constancy of the latter in most cases more reliable than observations through years of the temperature of the air in the interior of a continent, which is subject to great fluctuations; and differences as great as those referred to on page 73 even between the mean monthly temperature of the air of various years can never occur in the temperature of the sea. But publications of this nature should never be limited so as to give only mean values for great areas, as for instance those of the Netherland Institute, Whitley, and others; on the contrary, full tables of the single observations, with accurate designation of their places, should always be appended.

I would plead here for the importance of a chartographic representation of such subjects; the chart will better permit us to draw inferences and arrive at conclusions and results, than the best written book; both in connection will convey intuitiveness and clearness.

Private means, however, are rarely adequate for exhaustive labors of this kind; and if they are undertaken, as I have done in this case, the private publication will not suffice to do justice to the subject. The contents and the results of a considerable number of large-sized drawings had to be compressed into two small charts, which do not give the remotest idea of what was at hand, and was desirable to be brought before the public.

But my aims will be attained, if I should succeed through the two sketches, which answer so little my own wishes, to indicate the present status of the geography of the Gulf Stream, and further, to show the purposes of the North Polar expeditions, and what is intended to be reached by them.

The problem to be solved by a German North Polar expedition is not perhaps a cruise in the ice, or to the coasts of Greenland, or even to the North Pole; their purposes are absolutely scientific researches, in the first place, into the geography of the ocean, which will advance, among other subjects, also the knowledge of the phenomenon of the Gulf Stream. This includes observations of the currents, and of the surface and deep-sea temperature, the examination of drift wood, floating singly, as well as of accumulations of it, the collection of specimens of sea-water for analysis, and much more, all of which should begin on the coast of the German Sea, because this very sea, which washes our home shores, I confess it with shame, is in these respects nearly as little known as the North Pole itself. In this sense I have always conceived and urged a German North Polar expedition, and when, five years ago, for the first time, sketching the outlines of a programme for such an expedition, I placed the currents, and especially the Gulf Stream, directly at the head of it.[184]

Maury published his charts, which go to latitude 60° N., and are still so very valuable, at the expense of the Government of the United States; the Netherland Government has caused similar charts to be published, reaching to latitude 49° N.; British steamship companies, Danish war and merchant vessels, English and Swedish expeditions have extended these researches northward. German science also has moved of late to further these labors, by sending into the field expeditions which were fitted out from the limited means at its command, and from public contributions; the results of the first German expedition, and of that of Dr. Bessels and Dr. Dorst, the latter exclusively due to the generous munificence of a Rosenthal, are an honorable achievement.

I have labored for five long years incessantly, and have made sacrifices of all kinds to help extinguish the blot, that Germany should, in regard to scientific marine expeditions, remain any longer on a par with Turkey and Greece. I hope that the German Government now will lend its aid at least toward the thorough elaboration of all the material already collected and soon to be expected, as has been done in North America, Great Britain, the Netherlands, Denmark, Norway, Sweden, &c. German science, poor as its allotment in the governmental budget is, will never rest until the whole of the great, unknown, and mysterious region on the northern extremity of our globe is explored.

A. PETERMANN.

GOTHA, *June* 4, 1870.

FIRST SUPPLEMENT TO DR. PETERMANN'S PAPER.

THE TEMPERATURE OF THE NORTH ATLANTIC OCEAN AND THE GULF STREAM.

BY

Rear-Admiral C. Irminger.

COPENHAGEN, FEBRUARY 1870.

That the North Atlantic Ocean exercises a great influence on the climate of the countries, the coasts of which it washes, is generally known.

Nautical researches have proved that there is a current, or perhaps better, a drift in the North Atlantic Ocean toward the north, the source of which is pointed out, by observations of the temperature of the ocean, to be in southern and warmer regions. This drift, or this weak current, proceeds between Iceland and Norway up and into the Arctic Sea, while the waters which move wesward of it in a northern direction wash the southern and western coasts of Iceland, and continue their movement between Iceland and Greenland until they are met and checked by the "powerful Arctic Current," coming down from the Arctic Sea. This latter pushes its way southward past the northwest coast of Iceland and across to the east coast of Greenland, then along this and around Cape Farewell into Davis' Strait, and thence along the coast of Labrador and past Newfoundland.

If there was not the above-mentioned current toward the north in the North Atlantic, the so-called Greenland ice from the sea around Spitzbergen would drift, especially in prevailing northerly gales, to far more southern latitudes than is the case actually. This ice then would frequently drift to the west coast of Norway, to the Faroe and the Shetland Islands, &c.; and the ice which now drifts down between Iceland and Greenland, and along the east coast of Greenland, would fill the large bays of the west coasts of Iceland, and then find its way southward into the Atlantic; all of which does not take place.

It is this current toward the north which gives to Iceland, England, and Scotland the mild winter climate, is the source of the relatively mild winter on the Faroe Islands, and causes the harbors on the west coast of Norway, even beyond the North Cape, to be open for navigation throughout the entire winter; it is this current to the north which, washing the southern and western coasts of Iceland, tempers their climate so that the fishermen may throw out their nets during the entire winter in the open sea, and that ships may enter and leave Havne Fiord, in Faxe Bay, even in the strongest winter, as the sea is always open there. This drift from southern, warmer regions endows the North Atlantic with its high surface temperature, and it is striking how nearly the temperature of the surface of the sea agrees everywhere with that of the air; in weather fair in some degree, especially with a covered sky, there is indeed but very little difference in their temperature.

Besides the observations of the currents and the high temperature of the surface of the sea, we know a number of other facts which also prove that these great bodies of warm water come from a more southern climate. Tropical products, for instance, are frequently thrown on the coasts of Scotland, Norway, the Faroe Islands, Greenland, and other parts of the high north. Of these, I but name the great bean of the "*Mimosa scandens*," which is found there so frequently that everybody on this coast knows it. I myself found some near Husavik on the north coast of Iceland.

I am able to add other striking proofs of the extent of the current into the Arctic. I possess a fishing buoy of a common kind, as used at the Lofodes and on the coast of Norway, which was found in 1861 on the Seven Islands, northeast of Spitzbergen, where more of them were lying within a short distance on the shore. Again, not long ago I received from Lieutenant Falbe, of the Danish navy, who then was employed surveying in Greenland, a hollow globe of very thick green glass, of the form and size of a pretty large water-melon, which that officer had found on the shore at Julianehaab, in Greenland, between pieces of the so-called Greenland ice, which comes there from the sea around Spitzbergen. At first we could not make out this globe, but after various inquiries I learned that such globes have been used for some years by the fishermen of the Shetlands, and at places on the Norwegian coast, to support the nets in the water, in place of the common buoys, on account of their greater buoyancy. The globe in question had doubtless parted from a net and been driven by currents and winds into the Arctic, where it had frozen into the drift-ice, which then had drifted between Iceland and Greenland, along the east coast of Greenland, around Cape Farewell, and to Julianehaab, where the globe was found.

Subsequently another such globe was sent me by Overseer Müller, in Thorshavn, on the Faroes, who stated that of late they drift now and then upon these islands. Ast he current between the Faroe and Shetland Islands is generally running in a northeast direction, and the prevailing winds in this part of the Atlantic Ocean blow from the southwest and west, it might appear strange that these globes should drift to the Faroe Islands, but as the latter are so near to the Shetlands, and as these globes are so very buoyant, and consequently much exposed to the wind, it is readily conceivable how they can drift, with strong easterly winds, the short distance from the fishing grounds at the Shetlands to the Faroes, particularly as the direction of the currents in the North Atlantic Ocean is subject to considerable changes with strong winds from various quarters. It frequently happens in gales from the north and northeast, that vessels are set to the southward; I myself have been driven, under such circumstances, in twenty-four hours, more than twenty miles southward, where the current generally is to the northeast.

Speaking of these glass globes, I am reminded of the so-called "bottle experiments," resorted to so frequently under the impression that the direction of currents may be ascertained by them; but in many cases these experiments result in but very unreliable arguments for the direction, because the bottles used for the purpose are generally so light that they are propelled as much by the wind as by the current. If there are bottles to be used for ascertaining the direction of currents, they must, in order to escape the influence of the wind, be made expressly so thick and heavy that but little of the bottle can remain above the surface of the sea.

I have been for some time in possession of observations of the temperature of the surface of the sea, made in various parts of the Atlantic Ocean, partly by myself, and partly by naval officers and masters of merchant vessels who take interest in such researches, and to whom I had furnished reliable thermometers. The temperature of water and air was recorded daily in the log-books, generally each fourth hour. At the close of the cruise these journals were sent me to enable me to ascertain the exact places of the observations from the position of the ship recorded each noon.

These observations did show for the route between Fairhill and Cape Farewell, on a line directly across the entire North Atlantic, that the temperature of the surface of the sea is, in the same season, much the same from Fairhill (latitude 59° 28′ N., longitude 1° 55′ W. of Greenwich) to about longitude 30° W. of Greenwich, and sometimes even more west, the greatest difference being 4°.5 to 7°. Farther west the temperature decreases the more rapidly the nearer Greenland is approached, or the Arctic Current running along its coast, where the temperature of the surface of the sea sinks, in the vicinity of ice, or within the ice, frequently even below the freezing point.

This part of the Atlantic Ocean being but little frequented during the winter months, I could not obtain observations for January and February, and was but lately fortunate enough to get observations for December by Lieutenant Norman, who happened to be blocked up with the brig Elna in Frederickshaab, until the middle of November 1868, by the vast masses of ice which beleaguered the coast of Greenland during that winter, and through which he had to break finally.

The fall in the temperature of the surface of the sea from Fairhill to longitude 30°, or 40° W. of Greenwich, is by no means gradual; on the contrary there are bands where the water is of a higher, close to one where it is of lower temperature; and such bands are found on each passage across the Atlantic between Fairhill and Greenland.

The accompanying table will show the observations of the temperature of the sea between Fairhill and the meridians named. I have not embraced in it more than seven passages, as these, made at various seasons, will suffice to give an idea of the temperature of the North Atlantic Ocean in this region, where the currents from the southern zone exert their beneficial influence.

To inquire into the relations of the temperature of one and the same season in various years, I have compared a passage in May 1844, and one from September to October 1846, with two made in about the same season of other years, in May 1868, and October 1867.

Taking into consideration the difference in the dates and the positions, although they are but slight, as also the higher temperature of the surface of the sea in the warmer season, it will be seen that the mean temperatures agree pretty well. The passage in May 1844 was somewhat earlier than that in May 1868; they differ in mean temperature 1°.2; the passage in September and October 1846 was earlier than that in October 1867, and differs from the latter 0°.85. If these passages in the various years had corresponded in their dates, the mean temperatures would doubtless agree still better.

Although the passages recorded in the table were made, some in the warm and others in the cold season, the fluctuation of the mean temperature between Fairhill and that western meridian up to which the surface of the sea does not show, in the same season, greater changes in the temperature than from 4°.5 to 7°, is about the same for all passages together, viz., 5°.8; the mean temperature of March as the minimum being 45°.7, and that of July as the maximum 51°.6. The difference between the highest and the lowest temperature of the sea observed on this line of the Atlantic Ocean is 10°.8, as there were observed at Fairhill on the 15th of March 43°.7, and in latitude 59¾° N., longitude 4° W. of Greenwich, on the 8th of July, 54°.5. To the west of the meridians named the temperature fell more rapidly, the more so the nearer to Greenland.

As already stated, I have no observations for January and February, but the temperature of these months will probably not differ much from that in December and March, because the mean temperature of the sea at Thorshavn for the months of December, January, February, and March differs, according to the daily observations at the Faroe Islands in 1846 and 1847, but 2°.9,[185] and probably the temperature is more constant in the open sea than on shore at Thorshavn, which is closed in by land.

The slight change, however, in the temperature of the surface of the sea which is found on this line, cannot be exemplified in the same manner as regards the limits of streamlets or bands of warm water which furrow the Atlantic there.

The table shows that the temperature of the warmest bands is defined frequently pretty sharply against the waters which run through them. The table also shows where these warmer bands are found, and I have given, in a column of it, as accurately as possible their extent from east to west in nautical miles. To be able to define the limits, I have selected only the warmest bands; it will easily be seen that had I allowed a wider range to the observed temperatures, these bands would have been accounted for as much broader, especially where they are not in some measure well defined.

It is impracticable to establish in which longitudes these bands may be found, in the various seasons, because there is no regularity in their limits nor in their extent, as will be seen by comparing the passage in May 1844 with that in May 1868, and that in September and October 1846 with that of October 1867.[186]

The observations, however, show the fact that such bands are crossed on *each* passage, and that generally two are found—one a little west of Fairhill, and the other far more westward in the broad ocean, sometimes even west of the meridian of Cape Reikianäs, the southwesternmost point of Iceland, which lies in longitude 22° 50′ W. of Greenwich. Both these bands possess about the same temperature.

I have recorded in the table only seven passages, because the observations of the other passages which were furnished me exhibit temperature relations similar to the above in about the same longitudes.

The Gulf Stream has been described so often, and is so generally known, that it needs not to be discussed here. I will only state that not only its limits are very changeable in the various seasons, but that also the width of its warm waters is subject to very great changes, as has been established by many researches. I will but add, as a proof, that the warm waters of the Gulf Stream between the Bermudas and Halifax had a width, in February 1820, of 140 miles, but in May of the same year of 300 nautical miles; in June 1847 they were, in about the same place, 146 miles across; they were then again about as broad as in February, 1820.[187]

I will further recall to the mind that a branch of the Gulf Stream sets in a northeast direction toward the coasts of Europe, and that this very perceptible current traverses a great length of the ocean, maintaining a temperature of some degrees above the mean temperature of the ocean.

That the Gulf Stream should expand over the entire North Atlantic Ocean, wherever the temperature of the surface is nearly uniform and relatively high, I deem less probable, as the warm water of the Gulf Stream is not found at considerable depths,[188] and its volume therefore cannot be as great as some may suppose. It is, besides, a fact that the warm water of the Gulf Stream is but little apt to mix with the adjoining sea-water.

It must be borne in mind that the nearly uniform and relatively high temperature of the surface of the ocean, on the line from Fairhill in the direction of Cape Farewell, extends between the meridians 30° and 40° W. of Greenwich. Fairhill lies nearly two degrees west of Greenwich. Even if these two degrees are subtracted from the degrees of longitude denoting the meridians where the high temperature is still found, it may be assumed that the nearly uniform and high temperature of the surface of the sea extends thirty degrees of longitude, or at least nine hundred nautical miles west of Fairhill.

The higher temperature of the many thousand square miles of the North Atlantic from about 40° north latitude, must be ascribed, as I take it, to the drift or current of the broad Atlantic Ocean, and, since a part of the Gulf Stream follows the movement of the ocean toward the north, it is extremely probable that only the highest tempered bands of water which were found on all the passages between Fairhill and Greenland, are branches of the Gulf Stream itself, which through the constantly following warm waters of the Gulf Stream maintain a higher temperature than that of the other parts of the ocean.

That these warmer bands are found at one time more to the east, at another more to the west, has its cause, as I have ventured to express already some years ago,[189] in the Gulf Stream meeting the Arctic Current in the vicinity of the Newfoundland Banks, and their pressing against each other; when the Arctic Current is stronger than the Gulf Stream the latter turns more to the east, otherwise the Arctic Current gives way. Prevailing winds, particularly those athwart the currents, contribute doubtless to push these warmer bands more or less to the east or west.

To convey an idea of the cooling of the sea in the progress of the body of water toward the north, I will give here the mean, for five years, of the observations of the temperature of the surface of the sea, which were obtained on board of the steamships of the Cunard line from Liverpool to New York from longitude 10° W. of Greenwich to the Newfoundland Banks;[190] the track of these vessels lies ten or eleven degrees more to the southward than the line between Fairhill and Greenland:

Temperature.	On the Newfoundland Banks.	Longitude W. of Greenwich.							Thermometer.
		40°	35°	30°	25°	20°	15°	10°	
	°	°	°	°	°	°	°	°	
Temperature of the surface, mean of 5 years...	39	57.2	56.3	56.3	56.1	56.3	55.	54.3	Fahrenheit.

The temperature of the surface of the sea on the Newfoundland Banks, from a mean of five years, is lowest in January, 30°; and highest in September, 52°. On the other parts of the line it is warmest in August in 40° W. of Greenwich, 61°; and coldest in February in 10° W. of Greenwich, 50°.

The warm bands may be traced much higher north; in regard to those which continue their course between Iceland and Norway, I will state a few instances to prove that they are found even in the Arctic Sea.

Beechey, in his well-known work on his voyage of northern discoveries,[191] states that Parry, on his passage from Sarö to Spitzbergen, found a continuation of the Gulf Stream in latitude 73° N., longitude 8° E. of Greenwich, "where the temperature, as with Captain Buchan, fell from 39° to 32° Fahrenheit, and continued at or below this degree during the remainder of the voyage."

Scoresby remarks:[192]

In some situations near Spitzbergen the warm water not only occupies the lower and mid regions of the sea, but also appears at the surface; in some instances, even among ice, the temperature of the sea at the surface has been as high as 36° or 38°, when that of the air has been several degrees below freezing. This circumstance, however, has chiefly occurred near the meridians of 6° to 12° E. of Greenwich, and we find, from observations, that the sea freezes less in those longitudes than in any other part of the Spitzbergen Sea.

Again, when Captain Södring was about to sail in 1860 with the steamer Fox from Copenhagen to the Arctic, on a sealing cruise, I begged him to observe the temperature of the surface of the sea. The following is an abstract of his journal:

1860.	Latitude north.	Longitude from Greenwich.	Temperature of air.	Temperature of surface of sea.
	° ′	° ′	°	°
February 28, at Lindesnäs			36.5	38
February 29	58 32	4 22 E.	39	39
March 1	59 40	3 40 E.	37	41
March 3	61 56	0 08 E.	41	45.5
March 4	63 37	2 15 W.	40	40
March 5	64 40	2 59 W.	34	38
March 6	65 15	1 35 W.	38	39
March 7	66 21	1 26 W.	34	41
March 8	68 31	4 15 W.	33	34
March 9	70 30	7 47 W.	32	28.6 } in the ice.
March 10			12	28.6 } in the ice.

That there should be, so near the Arctic Circle, and after the influences of a long, cold winter, a belt where the water has a temperature of 41°, is again a proof of the existence there of a current from southern regions, and doubtless connected with the Gulf Stream.

Between latitude 62° N., and the south coast of Iceland, from about longitude 18° W. of Greenwich, toward Cape Reikianäs, the current proceeds northwest.[193]

In regard to the warm bands which are found to the west of longitude 18° W. of Greenwich, as shown in the table, it may be assumed with certainty that they take their course between Iceland and Greenland, and wash the southern and western coast of Iceland. The temperature of the surface of the sea proves sufficiently the existence there of a warmer current.

Should some one wish to become better acquainted with the temperature of the surface of the sea on the south and west coasts of Iceland, he is referred to the chart appended to my memoir on the currents and the ice around Iceland.[194] I will state here, however, that 50°.9 were observed on August 31, east-southeast of Cape Reikianäs; 51°.8 in August, 1859, a few miles northwest of Snefelsjökul, in about latitude 65° N.; and 49°.1, in June, in nearly 66° N latitude, northwest of Patricksfiord, in the vicinity of the Arctic Current, in which, only 30 nautical miles more to the north, but 32°.5 were found at the surface of the sea.

As the chart just alluded to reaches only to longitude 30° W., I will add here yet a few observations, which were made by Captain Knudson in the brig of war Queen, in 1859, on a cruise from Iceland to our colonies in Greenland, and back to Iceland:

Date.	Position.		Temperature.	
	Latitude N.	Longitude W. of Greenwich.	At the surface.	In various depths.
	° ′	° ′	°	°
June 28, 1859	61 12	33 00	46.4	200 fathoms...43.7
June 29, 1859	60 27	35 34	45.0	300 fathoms...44.1
June 30, 1859	59 35	38 09	44.6	300 fathoms...44.4
August 8, 1859	60 10	36 21	48.6	300 fathoms...45.0

On the 8th of August the ship was in about the same place as on June 29; it appears that the warmer water, in the mean time, had approached nearer to the coast of Greenland, perhaps also partly through the influence of the sun; it was scarce two hundred nautical miles distant from it. The temperature on August 8 agrees pretty well with that recorded in the appended table of passages to Greenland, (that of 1869,) when the temperature at the surface on July 28, in latitude 56½° N. and longitude 38° W. of Greenwich, (about three and one-half degrees more southward,) was found to be 50°.

How far to the westward single bands of a relatively higher temperature are found sometimes, I can show by an instance in the year 1869. Captain Bang, when returning from Greenland in the brig Constance, had on May 6 to beat against the wind between latitude 53½° and 54° N., and longitude 40° and 41° W. of Greenwich. From the Greenland coast, where no ice had been seen, to that place the temperature of the sea had risen regularly from 33°.6 to 41° and 42,° when it pretty suddenly rose to 45°.5. On account of this rise observations were made at shorter intervals; the thermometer kept as high; it even rose to 46°.5, at which temperature of the water sixteen nautical miles were made on a north-northwest course. The temperature of the air above this warmer band also rose from 41° to between 43°.2 and 45°.5. A few miles to the eastward the temperature fell to 42°.6 and 41°.7; but in longitude 39¾° W. of Greenwich the thermometer showed again 45°.5 as the temperature of the sea at the surface; it fell, however, soon to 44°.4 and 43°.2, and remained mostly between 41° and 43°.2 up to latitude 58° N., longitude 30½° W., where the temperature of the sea, as well as of the air, advanced again to 45°.5, and soon to 47°.7 and 48°.9.

On all the seven passages recorded in the appended table, two warm bands have been observed, except in the passage of the brig Elna in December 1868, which exhibited a third small band in about longitude 13° W. of Greenwich, and of the brig Constance in March 1869, for which I have only recorded the western band, as from Fairhill to about longitude 15¾° W. the sea was found to be colder at the surface than the mean temperature of the entire passage, viz., 45°.7; between the meridians 7½° and 11½° W. of Greenwich, however, the temperature was found to be 46° to 46°.6, but although this is higher than the mean, I deemed the difference not great enough to record this as a warmer band.

From the above discussion, it appears to me probable that the warmer bands in the North Atlantic Ocean are branches of the Gulf Stream. The western warm band is connected, doubtless, with that part of the Gulf Stream which approaches nearest to the Newfoundland Bank; while the eastern band corresponds to that part which, in Rennell's opinion, proceeds toward Europe, from whence it turns still more to the northward, and so shapes the course of the eastern band more easterly and nearer to Fairhill.

The mild winter climate, so prevalent on the western coasts of Europe, cannot, however, in my opinion, be ascribed solely to the Gulf Stream, but is due principally to the great and broad Atlantic Ocean, above which there is in the colder seasons a relatively high temperature, which by the prevailing western and southwestern winds is carried to the coasts of Europe.

Temperature on the surface of the North Atlantic Ocean between the Orkney Islands and Cape Farewell, 56° to 60° N. latitude.

Observer and date.	Mean temperature of the surface of the sea between Fairhill and position A.				Temperature.		Highest temperature.				Lowest temperature.				Greatest difference.
	Position A.		Date.	Temperature.	Fairhill.	Position A.	Temperature.	Position.		Extent east to west in nautical miles.	Temperature.	Position.		Date.	
	Latitude N.	Longitude W. of Greenwich.						Latitude N.	Longitude W. of Greenwich.			Latitude N.	Longitude W. of Greenwich.		
	°	°					° °	°	° °	°	°	°	°		
Captain Holböll to Greenland, May 1844.	59½	31	May 7 to 23.	46.8	May 7, 45° 5′	May 23, 44° 6′	47.7 to 48.9	59¾	5 to 9	120	44.4	60½	28½	May 21	4.5
							47.7 to 48.9	59½	21 to 22½	40					
Captain Holböll from Greenland, September and October 1846.	59½	30½	Sept. 27 to Oct. 3.	51.1	Oct. 3, 50° 5′	Sept. 27, 49° 3′	52.2 to 53.1	60	21 to 24	80	49.3	59½	30½	Sept. 27	3.8
							52.2 to 52.7	59½	8 to 9	25					
Captain Bang to Greenland, May 1868.	58	32	May 13 to 26.	48.0	May 13, 47° 8′	May 26, 45° 5′	49.3 to 50.0	60½	6 to 7½	45	45.5	58	32	May 26	4.5
							49.3 to 50.0	59¾	14½ to 19	130					
Captain Bang from Greenland, October 1867.	59¼	30	Oct. 9 to 23.	50.3	Oct. 23, 50° 7′	Oct. 9, 48° 2′	51.1 to 51.8	60½	19½ to 20½	30	48.2	59¼	30	Oct. 9	3.5
							51.1 to 51.8	60	2 to 5	90					
Captain Bang to Greenland. March 1869.	57	33	Mar. 15 to 28.	45.7	Mar. 15, 43° 7′	Mar. 28, 44° 4′	47.7 to 48.9	59⅓	22 to 24¾	80	43.7	at Fairhill.		Mar. 15	5.2
Captain Bang to Greenland, July 1869.	56½	38	July 7 to 28.	51.6	July 7, 51° 8′	July 28, 50° 0′	52.2 to 54.5	59¾	3 to 5	60	48.9	60¾	7¼	July 10	5.6
							52.2 to 53.4	60½	26 to 30	120					
Lieutenant Normann from Greenland, November and December 1868.	56	33	Nov. 26 to Dec. 15.	46.7	Dec. 15, 47° 1′	Nov. 26, 44° 4′	47.7 to 48.4	57	20 to 28	250	44.4	56	33	Nov. 26	4.0
							47.7	59¾	12¾ to 13¼	12					
							47.7	60½	2 to 5	90					

METEOROLOGICAL OBSERVATIONS

DURING

A WINTER STAY ON BEAR ISLAND,

FROM AUGUST 6, 1865, TO JUNE 19, 1866.

By Sievert Tobiesen, Shipmaster.

Communicated by Professor A. E. Nordenskiöld, October 13, 1869.[195]

Bear Island is but small, and lies between about 74° 20′ and 74° 40′ N. latitude, and 18° 00′ to 19° 17′ longitude E. of Greenwich, isolated in the Polar Sea in a region bounded on one side by a weak branch of the Gulf Stream, and on the other side by a Polar Stream coming down from the northeast. Nearly the entire island is a flat plateau, at an elevation of about fifty to one hundred feet, from the southern and eastern parts of which two mountains rise to a height of from one thousand to one thousand two hundred feet; they are free from snow during the later part of the summer, but nearly always covered by clouds. The lower part of the island is covered with extensive heaps of stone, a product of the influence of the frost upon the sandstone rock beneath; there are bald fields of stones, hardly showing any vegetation, and innumerable shallow accumulations of sweet water which do not freeze to the bottom even in mid-winter. The plateau is so very steep toward the ocean that it is only possible in few places to climb the shore, which consists in general of wildly serrated rocks only accessible to birds.

At two points, the North and the South Harbor, the shore forms insignificant round deltas, which but a few decades ago were convenient resting places of the large walrus herds then rambling over the island from time to time. To hunt them Bear Island was visited often enough; there have been at times even small winter colonies, and the remains of a small winter hut may still be seen.

The walrus, and in its wake the hunter, however, retired soon to more northern and less accessible regions; but the tales of the hundreds of animals which frequently enough were slaughtered in a single day, and the bleaching skeletons of which cover now the sands of North Harbor, are still told and have caused the winter expedition, the observations of which we annex below.

This expedition was fitted out by the Norwegian shipmaster Sievert Tobiesen, at his own expense, to hunt walrus on the island during the fall and winter months. For this purpose he erected on the northern point of it, near the former walrus resorts, a neat and, when compared with the so-called Russian huts of Spitzbergen, commodious house of wood, which he had brought from Norway, and remained there with six men during the winter of 1865–'66. The results of hunting were very meager, by no means answering the expenses of the undertaking; only a single walrus and a few ice bears and foxes were killed; otherwise the stay was pleasant. All the participants of the expedition returned to Norway in good health, without, as has generally been the case with similar winter expeditions, having suffered at all from the scurvy. This may be ascribed, in the main, to the good order and discipline which Tobiesen proved energetic enough to maintain among his men.

He had brought out also a few, but unluckily incomplete, instruments, with which he carried on observations throughout his stay. Among them were:

1. A thermometer of Réaumur's scale, divided to whole degrees, which, at my request, was sent afterwards here to ascertain the corrections;[196] these were applied to the observations before entering them in the annexed table.

2. An aneroid barometer, divided to English inches. But this barometer had not been properly corrected, or even compared with a mercurial barometer before leaving Norway; it also fell in disorder during the winter from causes not known; there is therefore no certainty that the observations by it should not have serious errors, for which reason I did not deem it proper to embrace them in the table.

The hut, in which the expedition lived, lies, according to the determination by Captain Von Otter, in latitude 74° 38′ 55″ N., longitude 18° 48′ E. of Greenwich,[197] elevated about thirty feet above the surface of the sea, a few hundred paces from the shore of the walrus fiord.[198] The island is there perfectly level, with but a very slight rise toward the interior, and the distances to Mount Misery and Bird Mountain are quite considerable; the house, therefore, was not protected in any direction from the wind.

The following in regard to the ice is from Tobiesen's diary:

To the end of October it was possible to row in a boat to the southern part of the island. On the 2d of November a quantity of drift ice arrived from the northwest, north, and northeast, but drifted away again to the west in the night of the 4th. On the 6th no ice was to be seen, and on the 7th it rained. There were still seen eider-geese, alkes, and petrel on the 12th. On the 14th loose, porous ice drifted to the land, but parted again on the 16th. On the 19th ice again made its appearance, but birds were still seen. On the 22d and 23d porous ice came again, which on the 24th surrounded the island, so that no open water could be seen from the land, On the 26th the men could walk on the ice close to the shore, but at noon it parted in the middle and disappeared entirely during the day. On the 27th the ice came again close in, so that no open water could be seen. On the 30th it again went off; none was to be seen from the west coast; large flocks of petrel moved outside over the ice.

On the 1st of December ice set again toward the land; on the 4th it moved off, but returned on the 5th, covering the water all over; it moved off on the 7th and returned on the 10th. In the night of the 13th it bridged the water close to the land strong enough to support men, but disappeared again from time to time, so that the sea was now free and now covered again. On the 31st of December the sea was entirely free.

On the 5th and 6th of January snow fell so considerably that the sea become covered by a snow pap, which soon froze. The island now looked like a snow hill rising from a great snow plain; but the ice parted from time to time from the land, leaving the water next to the coast free to a width of a couple of rifle-ball ranges.

On the 23d two large flocks of birds were seen to fly over the ice from east to west; on the 24th an aurora borealis was observed.

On the 3d of February the ice broke, but froze again on the 5th. On the 10th the sea was again free, with the exception of a few isolated fields. On the 11th eider-geese were seen swimming on the water. On the 18th loons were seen. On the 24th the sea froze again as far as the eye could reach.

On the 2d of March the ice broke, disappeared at times, and came again. On the 30th it was in pieces, as far from the shore as could be seen; it closed, however, soon again. On the 18th of April the entire sea was covered by ice. On the 23d none was to be seen toward the north, but it returned on the same day with a westerly wind.

On the 6th and 7th of May much of the ice drifted away, but new came in its place with an easterly wind. In the first week of June the land began to be free of ice and snow, but the sea was covered in all directions with drift ice, which, however, became less by degrees; on June 17th, the day of departure, great masses still drifted past the island.

Meteorological observations at Bear Island.

Date.	8 a. m.		2 p. m.		8 p. m.		Daily mean temp.	Sky.
	Temp.	Wind.	Temp.	Wind.	Temp.	Wind.		
1865.	°		°		°		°	
Aug. 6	40	W.	45	W.	40	W. S. W.	41. 6	Fog and thick fog.
7	45	W. S. W.	42	N. W.	40	W.	42. 6	Fog.
8	42	S. W.	42	S. W.	42	....	42. 4	Fog and foggy.
9	42	S.	40	N.	38	N. E.	40. 1	Fog.
10	33	N. E.	33	N. E.	31	N. E.	32. 5	Fog.
11	42	N. E.	40	N.	40	Calm.	41. 0	Foggy.
12	42	S. E.	42	S.	40	S.	41. 7	Foggy and clear.
13	38	Calm.	40	Calm.	38	Calm.	38. 8	Foggy.
14	42	Calm.	42	Calm.	40	Calm.	41. 7	Clear, foggy, clear.
15	34	Calm.	35	Calm.	33	N. N. E.	34. 3	Clear, fog, clear.
16	42	N.	38	N.	38	N. N. W.	39. 4	Clear.
17	38	N. N. W.	35	N.	35	W.	36. 3	Clear, fog.
18	40	W.	38	W.	38	W.	38. 8	Fog, clear.
19	38	S. S. W.	40	S.	38	S.	38. 8	
20	38	W. N. W.	38	N. W.	33	N. N. W.	36. 3	Covered, clear.
21	35	N. W.	38	N. W.	38	N. W.	37. 2	Covered, clear.
22	40	W.	40	W.	38	W. N. W.	39. 4	Foggy.
23	38	W. N. W.	40	W.	38	S. E.	38. 8	Fog.
24	33	N.	32	N.	32	N.	32. 7	Covered, clear.
25	33	N.	35	N. E.	35	N. N. E.	34. 7	Clear.
26	35	E.	33	N. E.	31	Calm.	33. 1	Clear, covered.
27	33	N. N. E.	33	N. N. E.	33	Calm.	33. 1	
28	31	N.	33	N.	33	N.	32. 4	Covered.
29	35	N. W.	38	N. N. W.	33	Calm.	35. 4	Foggy, clear.
30	33	N. N. E.	33	N. N. E.	31	N. N. E.	32. 4	Foggy, clear.
31	31	N.	31	N.	31	N.	30. 9	Clear.
Monthly	mean	....	......	....	......	....	37. 2	
Sept. 1	26	N.	30	N.	28	N.	28. 0	Snow drifts.
2	28	N.	28	N.	28	N.	28. 2	Snow drifts and fog.
3	31	N.	31	N.	31	N.	30. 9	Covered, clear.
4	33	S. S. E.	40	S.	34	S. S. W.	35. 8	Snow, covered, fog.
5	39	Calm.	34	S. E.	33	N. E.	35. 6	Covered, rain.
6	33	N. N. W.	35	S. W.	33	W. N. W.	33. 8	Fog, clear.

Meteorological observations at Bear Island—Continued.

Date.	8 a. m.		2 p. m.		8 p. m.		Daily mean temp.	Sky.
	Temp.	Wind.	Temp.	Wind.	Temp.	Wind.		
1865.	°		°		°		°	
Sept. 7	31	N. N. W.	33	S. W.	33	N. N. W.	32. 5	Fog.
8	32	N. N. W.	33	N. N. W.	33	N. N. W.	32. 7	Clear.
9	31	N.	29	N.	29	N. N. E.	30. 0	Clear.
10	32	N. E.	38	S. E.	35	S.	35. 2	Snow, fog, and rain.
11	38	S. S. W.	41	S. S. W.	35	Calm.	38. 1	Covered.
12	33	N. W.	34	W. N. W.	33	N. W.	33. 6	Clear, covered.
13	35	S.	40	S. E.	34	S. S. E.	36. 7	Covered, fog, rain.
14	35	E.	33	N. E.	33	N.	33. 8	Rain, fog.
15	33	W. N. W.	33	N. N. W.	33	W.	33. 1	Covered, snow, cov'd.
16	31	W. N. W.	33	N. E.	31	E.	31. 6	Covered, clear.
17	35	E. S. E.	40	S.	38	S.	37. 8	Snow, thick fog.
18	45	S.	40	S.	35	S.	40. 1	Covered, rain, covered.
19	38	S. W.	38	S. W.	33	S. W.	36. 3	Fog, covered.
20	34	N. W.	......	W. N. W.	32	Calm.	32. 7	Snow drifts, foggy.
21	38	S.	43	S.	42	S.	41. 2	Rain.
22	38	S.	40	S. W.	40	S. W.	39. 4	Fog.
23	40	S. S. W.	40	S. S. W.	38	S, W.	39. 4	Covered, foggy.
24	34	W.	33	W. S. W.	31	N. W.	32. 9	Fog, snow.
25	33	N. W.	33	N. W.	32	....	32. 7	Covered, fog, snow drifts.
26	31	W. N. W.	32	N. N. W.	30	N. W.	30. 8	Covered.
27	28	Calm.	31	N. N. E.	30	N. N. W.	29. 5	Covered.
28	30	N. W.	31	N. N. W.	31	N. W.	30. 4	Covered.
29	31	S. E.	32	E. S. E.	31	E. S. E.	31. 3	Fog.
30	28	N.	27	N.	27	N. W.	27. 3	Snow drift, fog.
Monthly	mean	....	......	....	......	....	33. 8	
Oct. 1	28	Calm.	31	W. S. W.	30	W. S. W.	29. 5	Covered, fog.
2	33	W. S. W.	35	S. S. W.	35	S. S. W.	34. 7	Snow, rain.
3	33	W.	31	N. N. W.	31	N. N. W.	31. 6	Rain, snow.
4	31	S. E.	31	N. W.	30	W.	30. 4	Snow, covered.
5	30	N. N. E.	30	N. W.	28	N. E.	29. 1	Snow, clear.
6	30	E.	26	E.	23	E.	26. 1	Clear.
7	28	N. E.	30	N. E.	30	N. E.	29. 1	Fog.
8	23	S.	30	W. S. W.	31	S. W.	28. 0	Foggy, snow.
9	32	S. W.	28	N. W.	27	N. W.	29. 1	Covered.
10	31	N.	28	N. E.	27	N. E.	28. 6	Snow, covered.
11	23	N. E.	21	S. E.	22	S. E.	21. 9	Covered, fog.
12	23	E.	22	E.	22	N. N. E.	22. 3	Snow.
13	24	N. E.	27	N. E.	28	E. N. E.	26. 4	Covered.
14	28	E.	30	N. E.	30	E.	29. 1	Covered, snow.
15	30	E.	30	E.	28	E.	29. 1	Snow, fog.

Meteorological observations at Bear Island—Continued.

Date.	8 a. m.		2 p. m.		8 p. m.		Daily mean temp.	Sky.
	Temp.	Wind.	Temp.	Wind.	Temp.	Wind.		
1865.	°		°		°		°	
Oct. 16	28	N. E.	28	N. E.	27	E. N. E.	27.7	Snow, fog, aurora borealis.
17	28	N. E.	27	N. E.	28	N. E.	27.7	Fog, little aurora borealis.
18	28	N. E.	28	N.	28	E.	28.2	Foggy, covered.
19	28	N. E.	21	E.	19	E.	22.3	Clear, aurora.
20	21	N. E.	19	E. S. E.	24	E.	21.2	Clear, weak aurora.
21	28	N. E.	28	E.	30	E.	28.6	Covered, weak aurora.
22	30	N. E.	30	N. E.	30	N. E.	29.5	Covered, fog.
23	24	N. N. E.	23	N. N. E.	22	N.	23.2	Fog.
24	21	N. N. W.	22	N. N. W.	19	E.	20.3	Covered, aurora.
25	17	S. E.	19	S. E.	21	S. E.	18.5	Clear.
26	21	N. E.	23	E.	27	N. E.	23.6	Snow, fog.
27	31	N. N. E.	31	N. N. E.	31	N. E.	30.8	Fog.
28	30	E. N. E.	30	E. N. E.	31	N. E.	30.0	Fog.
29	31	N.	31	N. E.	31	N. E.	30.8	Fog, covered.
30	31	E. N. E.	31	E. N. E.	28	E. N. E.	30.0	Snow and fog.
31	24	N. N. E.	24	N. N. E.	23	N. N. E.	24.1	Fog.
Monthly	mean	....	.....	....	.....	....	27.1	
Nov. 1	24	N. N. W.	24	N. N. W.	26	N. N. W.	24.8	Covered, fog.
2	23	N. N. W.	22	N.	23	N.	22.7	Covered, fog.
3	27	N. E.	30	N. E.	31	E. N. E.	29.1	Foggy.
4	31	S. E.	28	S. E.	28	E. S. E.	29.1	Covered, clear, cov'd.
5	21	S. E.	26	S. E.	30	W. S. W.	25.5	Clear, covered, fog.
6	28	S. W.	27	S.	27	S. S. W.	27.7	Snow, covered, fog.
7	35	S. S. W.	34	S. S. W.	26	N. W.	31.7	Rain, fog.
8	27	S. W.	33	S. W.	33	S. W.	31.1	Fog.
9	31	W. S. W.	31	S. W.	28	W. N. W.	30.0	Snow and fog.
10	22	W.	21	W.	20	W.	20.7	Snow.
11	17	S. W.	21	S. W.	23	W.	20.1	Covered.
12	23	N.	23	N.	21	W. N. W.	22.3	Covered, weak aurora.
13	19	W. N. W.	19	N. W.	17	N. N. W.	17.8	Snow, clear.
14	14	N. N. W.	17	N. N. W.	17	N.	15.8	Covered.
15	19	S.	24	S.	31	S. S. W.	24.6	Fog, snow, rain.
16	31	W. S. W.	32	W. S. W.	31	S. W.	31.3	Covered.
17	33	S. W.	33	W. S. W.	22	N. W.	29.3	Rain.
18	17	E. N. E.	17	E. N. E.	23	E. N. E.	19.4	Snow.
19	30	S. E.	35	S. S. W.	35	S. S. W.	33.3	Snow, rain.
20	33	W. S. W.	30	N.	23	N. N. W.	28.6	Covered, snow.
21	19	W. N. W.	17	N. N. W.	11	N. W.	15.1	Covered, snow, cov'd.
22	14	N.	18	S.	18	W.	16.2	Fog, covered, aurora.

Meteorological observations at Bear Island—Continued.

Date.	8 a. m.		2 p. m.		8 p. m.		Daily mean temp.	Sky.
	Temp.	Wind.	Temp.	Wind.	Temp.	Wind.		
1865.	°		°		°		°	
Nov. 23	8	N.	7	N.	7	N.	7.7	Covered.
24	1	E. N. E.	1	N. E.	3	N. E.	1.6	Fog, covered.
25	3	N. E.	5	N. E.	7	N. E.	4.8	Covered, fog.
26	15	N. E.	20	S. E.	23	S. E.	20.1	Covered, fog,
27	27	E.	27	E.	27	N. E.	27.1	Snow.
28	24	N. N. E.	23	N. N. E.	23	N. E.	23.5	Snow, fog.
29	21	N.	21	E.	19	N. E.	19.9	Covered, snow.
30	20	S. S. W.	22	W.	21	E.	20.0	Snow, covered.
Monthly	mean	....	......	....	......	....	22.3	
Dec. 1	19	E. S. E.	24	W.	10	N. W.	17.4	Snow, covered.
2	8	N. W.	10	N. E.	6	N. E.	+ 7.9	Snow.
3	— 3	N. E.	— 4	N.	— 2	N. N. E.	— 3.6	Covered.
4	— 2	S. S. E.	14	S. S. W.	19	S. W.	+10.2	Snow, fog.
5	27	S. W.	26	N. W.	17	N. W.	23.2	Fog, clear.
6	23	W. S. W.	26	S. W.	26	W.	24.8	Covered, fog.
7	28	S. W.	33	W.	31	S.	30.6	Covered, fog.
8	34	S.	33	S. W.	28	N. W.	32.0	Fog, rain.
9	31	S. W.	30	S. W.	30	E. N. E.	30.0	Fog, snow.
10	28	S.	20	N. W.	14	N. W.	20.8	Fog, snow, covered.
11	17	N. N. W.	11	E. S. E.	14	S. E.	13.8	Snow.
12	32	W. S. W.	28	W. S. W.	21	N. W.	27.0	Snow, covered.
13	5	N. N. W.	3	N. N. W.	— 4	N.	+ 1.4	Covered, weak aurora borealis.
14	—12	N. N. E.	—13	N. N. E.	— 3	S.	— 9.0	Clear.
15	— 6	N. E.	—11	N. N. E.	—16	N. E.	—10.5	Covered, clear, snow.
16	—16	N.	— 6	N. W.	— 2	N. N. W.	— 8.1	Snow, covered.
17	3	N. W.	— 5	Calm.	— 5	S.	— 2.2	Clear.
18	— 6	E.	— 7	E. N. E.	5	S. E.	— 2.6	Clear, snow.
19	23	S. W.	23	W. S. W.	18	N. W.	+21.4	Snow, clear.
20	7	E.	11	E.	17	S. E.	11.5	Covered, snow.
21	15	N.	15	N. W.	12	N. W.	14.2	Covered, snow, clear, aurora borealis.
22	10	N. E.	5	N. E.	0	E.	4.8	Snow.
23	3	E.	19	E. S. E.	28	S. E.	16.5	Snow.
24	33	W.	31	W. S. W.	30	W.	31.3	Rain, fog.
25	35	S.	34	W. S. W.	33	S. W.	34.3	Rain, fog.
26	35	S. S. W.	33	S. W.	31	W. N. W.	33.1	Rain, snow.
27	21	W. N. W.	20	N. W.	20	W.	19.8	Snow.
28	33	W. S. W.	34	W.	33	W.	33.6	Rain, fog, covered.
29	35	S.	35	S. W.	31	W.	33.8	Rain, covered, clear.

Meteorological observations at Bear Island—Continued.

Date.	8 a. m.		2 p. m.		8 p. m.		Daily mean temp.	Sky.
	Temp.	Wind.	Temp.	Wind.	Temp.	Wind.		
1865.	°		°		°		°	
Dec. 30	30	S. S. E.	30	S. E.	31	E. S. E.	30.0	Covered, clear, cover'd.
31	33	S. S. E.	33	S. S. W.	33	S. S. W.	33.1	Covered.
Monthly	mean	....	.....	....	.....	....	16.7	
1866.								
Jan. 1	31	E.	31	S. E.	23	S. E.	28.4	Fog, snow, clear.
2	33	S. S. E.	31	S. S. W.	31	S. S. E.	31.6	Covered, foggy, cov'd.
3	30	S.	23	S. W.	22	S. S. E.	24.8	Fog.
4	21	E. S. E.	17	E.	17	E.	17.8	Snow.
5	17	E. N. E.	10	E. N. E.	5	E. N. E.	10.2	Snow, covered.
6	4	E. N. E.	7	E.	12	E.	7.7	Snow.
7	11	E. N. E.	0	N. E.	— 4	N. E.	+ 2.3	Snow, fog.
8	—18	N. E.	—19	N. E.	—18	E.	—18.4	Clear, aurora.
9	—12	E. N. E.	—16	S.	—10	S.	—12.1	Clear, aurora.
10	0	S. S. E.	5	N. E.	— 2	N. E.	+ 0.7	Clear, covered, clear, aurora.
11	0	N.	0	N. E.	— 4	N. E.	— 1.0	Snow, clear, aurora.
12	— 5	E.	3	E. N. E.	5	Calm.	+ 1.0	Covered, snow.
13	10	S. E.	14	S. E.	7	N. N. E.	10.4	Covered, snow.
14	— 2	E. S. E.	7	E. S. E.	3	E.	+ 2.3	Covered, snow, clear, aurora.
15	— 5	E. N. E.	— 6	E. N. E.	— 2	E.	— 4.2	Covered, clear, aurora.
16	— 1	E. S. E.	— 1	E.	5	E.	+ 1.0	Clear, covered, snow.
17	12	E.	12	E.	— 4	S. E.	6.8	Snow, covered, clear, aurora.
18	5	E.	5	N. E.	12	E. N. E.	7.2	Snow, fog.
19	4	E. N. E.	— 4	N. E.	0	N. E.	0.0	Covered, snow.
20	3	N. E.	3	E. N. E.	3	E. N. E.	2.5	Snow, covered.
21	6	N. E.	6	N. E.	7	N.	6.1	Fog, snow.
22	10	E. N. E.	10	E.	5	N. E.	7.9	Snow, fog, clear.
23	6	E. N. E.	0	E.	3	S. E.	+ 2.7	Covered.
24	— 2	E.	— 5	E.	0	E.	— 2.0	Foggy, clear.
25	17	E. S. E.	28	S.	28	E.	+24.3	Covered, snow.
26	24	N. E.	19	N. E.	17	N. E.	19.9	Snow.
27	0	N. E.	1	N. N. E.	3	N. N. E.	+ 1.2	Covered, snow.
28	— 4	E.	— 6	N. E.	— 7	E. N. E.	— 5.4	Clear.
29	— 8	E. N. E.	— 5	E. N. E.	— 2	E.	— 4.8	Fog, covered.
30	—10	N. E.	—10	N. E.	— 7	N. E.	— 8.3	Clear.
31	— 8	E. N. E.	—10	E. S. E.	—10	E. S. E.	— 8.7	Clear.
Monthly	mean	....	.....	....	.....	....	+ 5.0	
Feb. 1	12	E. S. E.	15	S.	18	S.	14.9	Snow.
2	22	E.	28	E.	23	E. N. E.	24.3	Snow.

Meteorological observations at Bear Island—Continued.

Date.	8 a. m.		2 p. m.		8 p. m.		Daily mean temp.	Sky.
	Temp.	Wind.	Temp.	Wind.	Temp.	Wind.		
1866.	°		°		°		°	
Feb. 3	24	E.	24	E.	26	E.	24.8	Snow.
4	21	E.	21	E.	21	E.	20.8	Snow, covered.
5	5	E.	— 1	E. N. E.	— 2	E. N. E.	+ 0.5	Snow.
6	—10	E. N. E.	— 7	E. N. E.	14	E. N. E.	— 0.6	Snow, hail.
7	7	E. N. E.	14	E.	20	E.	+13.6	Snow, covered.
8	17	E.	19	E. S. E.	18	E.	17.6	Covered, snow, cov'd.
9	17	E.	19	E.	19	E.	17.8	Covered.
10	19	E. S. E.	21	S. E.	21	S. E.	19.9	Covered.
11	21	E. S. E.	21	E. S. E.	21	E. S. E.	20.8	Snow, covered.
12	21	E. S. E.	19	S. E.	20	E. S. E.	19.6	Snow, covered.
13	19	S. E.	21	E.	21	E. S. E.	19.8	Snow, covered.
14	23	S. E.	24	S. E.	27	S. E.	24.8	Covered.
15	30	S.	30	S.	28	S. S. W.	29.1	Snow.
16	28	E. S. E.	26	E. S. E.	24	E. S. E.	26.1	Covered, snow.
17	22	E. N. E.	26	N. E.	19	N. N. E.	22.1	Covered, snow.
18	13	S. E.	22	S. E.	30	S.	21.4	Clear, covered.
19	31	S.	31	S.	33	S.	31.6	Covered.
20	21	S. E.	26	S. S. E.	28	S. S. W.	24.8	Covered, clear, snow.
21	31	S.	32	S.	31	S.	31.3	Covered.
22	18	W. S. W.	19	W. N. W.	20	W. N. W.	18.5	Covered, snow.
23	21	E.	14	E.	11	E. N. E.	15.1	Snow.
24	5	E. N. E.	3	E. N. E.	2	E. N. E.	+ 3.2	Covered, snow.
25	0	E. N. E.	1	E. N. E.	— 2	E. N. E.	— 0.4	Covered.
26	— 2	E. N. E.	— 5	E. N. E.	— 2	E. N. E.	— 3.1	Covered.
27	6	N. E.	1	N. E.	0	N. E.	+ 2.3	Covered.
28	— 4	E.	— 2	S.	10	S.	1.2	Clear, foggy.
Monthly	mean	....	......	....	......	....	16.5	
Mar. 1	26	S. W.	28	S. W.	26	W.	26.6	Snow.
2	17	N. N. W.	7	N. E.	3	E. N. E.	+ 8.8	Fog, covered.
3	— 5	E. N. E.	— 6	E. N. E.	— 6	E. N. E.	— 5.4	Covered, clear.
4	— 5	E.	1	E.	1	E.	— 0.6	Clear, covered.
5	14	S. E.	17	N. E.	12	N. N. E.	+14.2	Snow.
6	— 8	N.	— 7	N.	— 5	N. E.	— 6.5	Covered, clear, snow.
7	—10	N. E.	— 8	E.	— 5	E.	— 7.1	Clear, snow.
8	19	S.	7	N. N. E.	— 9	N.	+ 5.5	Snow.
9	—14	N.	—11	N.	— 9	N.	—11.2	Clear, covered
10	—11	N.	— 7	N. N. E.	— 8	N.	— 9.4	Clear, covered, clear.
11	— 8	N. E.	— 8	N. E.	— 8	N. E.	— 8.1	Clear, covered.
12	— 8	N.	— 7	N. E.	— 8	N. E.	— 7.6	Clear, covered, clear.
13	— 2	E. N. E.	3	E.	3	E. N. E.	+ 0.9	Snow.
14	4	E. N. E.	5	N. E.	11	E.	6.4	Covered, foggy, snow.

Meteorological observations at Bear Island—Continued.

Date.	8 a. m.		2 p. m.		8 p. m.		Daily mean temp.	Sky.
	Temp.	Wind.	Temp.	Wind.	Temp.	Wind.		
1866.	°		°		°		°	
Mar. 15	15	E. S. E.	21	E.	22	E. S. E.	19.6	Covered, snow.
16	26	E.	29	E.	27	E.	27.0	Snow.
17	21	E.	21	E.	7	E. N. E.	+16.2	Covered, snow.
18	— 6	E. N. E.	— 7	E. N. E.	— 5	N. E.	— 5.6	Covered, snow.
19	— 6	E. N. E.	— 2	E. N. E.	— 5	E. N. E.	— 4.2	Covered.
20	1	E. N. E.	5	E. N. E.	1	E. N. E.	+ 2.5	Snow, covered.
21	— 2	E. N. E.	0	E. N. E.	— 1	E. N. E.	— 1.1	Covered.
22	— 6	E. N. E.	— 7	E. N. E.	— 8	N. E.	— 6.7	Covered.
23	—10	N. N. E.	— 7	N. E.	— 7	N. E.	— 7.6	Covered, clear.
24	— 5	Calm.	+ 3	E.	7	S.	1.6	Foggy.
25	21	E. N. E.	17	Calm.	— 2	Calm.	11.5	Snow, clear.
26	7	E.	30	W. S. W.	7	N. W.	14.7	Snow.
27	6	E.	17	E.	23	S. E.	15.1	Covered, snow.
28	33	S.	33	W. S. W.	33	S. W.	33.1	Fog.
29	33	S. S. W.	18	N. W.	12	N. N. W.	21.0	Covered, clear.
30	17	E.	27	E.	23	E.	22.1	Covered, snow.
31	34	S.	35	S. S. W.	31	S.	33.6	Fog, covered.
Monthly	mean	....	......	....	......	....	6.4	
April 1	31	S.	17	N. W.	12	N. W.	19.9	Covered, snow, cove'd.
2	17	W. N. W.	17	W. N. W.	15	W. S. W.	16.0	Covered, snow.
3	14	E.	14	E.	5	E.	11.1	Covered, clear.
4	10	E.	10	E. N. E.	6	E.	8.1	Covered.
5	7	E. S. E.	10	S. E.	17	S. E.	11.1	Covered, clear, fog.
6	30	S.	30	W.	10	N. N. W.	22.8	Snow, covered, snow.
7	19	N. W.	26	W.	22	W.	22.1	Clear, snow, fog.
8	32	W. S. W.	33	W. S. W.	33	W. S. W.	32.7	Fog, snow.
9	21	W. N. W.	15	N. W.	10	N. W.	15.1	Fog, snow.
10	14	N. W.	17	N. W.	12	N. W.	14.2	Clear, covered.
11	10	N.	11	N. N. E.	6	E.	8.6	Covered, snow.
12	10	E.	7	E. N. E.	6	Calm.	7.5	Snow.
13	7	E.	6	N. E.	3	E. N. E.	4.3	Snow, covered.
14	7	Calm.	14	S.	12	S.	11.1	Clear, covered.
15	18	S.	23	S.	23	S. W.	21.4	Covered, snow.
16	3	N. E.	— 1	N.	4	N. N. W.	+ 1.6	Covered, snow.
17	— 2	N. E.	— 5	N. N. E.	0	N.	— 2.2	Covered.
18	6	N. N. W.	7	N. N. W.	7	Calm.	+ 6.8	Covered.
19	14	W. N. W.	14	N. W.	10	S.	12.6	Fog, clear.
20	23	S.	27	S. W.	23	W. S. W.	24.4	Snow.
21	19	E. N. E.	18	E. N. E.	21	....	19.0	Fog, covered.
22	27	S. S. W.	31	W. S. W.	31	S.	29.5	Covered, snow.
23	33	W.	33	N. W.	31	W. N. W.	32.4	Fog.

Meteorological observations at Bear Island—Continued.

Date.	8. a. m.		2 p. m.		8 p. m.		Daily mean temp.	Sky.
	Temp.	Wind.	Temp.	Wind.	Temp.	Wind.		
1866.	°		°		°		°	
April 24	20	E.	14	E.	8	E.	14. 0	Snow, covered, clear.
25	8	N. N. E.	14	N.	14	Calm.	12. 2	Clear.
26	21	E. N. E.	21	Calm.	18	N.	19. 6	Fog, covered, clear.
27	5	N. E.	1	N. E.	0	E. N. E.	1. 8	Covered.
28	3	N. E.	7	N. E.	5	N. N. E.	4. 8	Covered.
29	7	E. N. E.	8	E. N. E.	10	E. N. E.	8. 4	Covered, foggy.
30	13	E. N. E.	15	E. N. E.	12	E. N. E.	13. 6	Foggy.
Monthly	mean	....	.....	....	.....	....	14. 0	
May 1	14	E.	19	Calm.	15	S. E.	16. 0	Clear.
2	20	Calm.	19	E. N. E.	14	E.	17. 4	Clear, covered.
3	9	E.	12	E.	11	E. N. E.	10. 4	Covered.
4	17	E.	20	E.	23	E. S. E.	19. 9	
5	26	E.	27	E.	22	E. N. E.	24. 8	Covered, snow.
6	21	E.	23	E.	26	E. S. E.	23. 2	Snow.
7	30	S. E.	28	E. S. E.	27	E.	28. 2	Snow, covered.
8	23	E. N. E.	20	E. N. E.	21	E. N. E.	21. 2	
9	21	E. N. E.	23	E. N. E.	23	E. N. E.	22. 3	Snow.
10	19	N. E.	21	N. E.	18	N. E.	19. 0	
11	14	N. E.	21	N.	21	N.	18. 5	Snow, clear.
12	14	N.	15	N.	14	N.	14. 4	Covered.
13	15	N. N. W.	17	N. N. W.	18	N. N. W.	16. 5	Snow.
14	21	N. W.	21	W. N. W.	21	N. N. W.	20. 8	Snow.
15	21	E.	21	E.	21	N. E.	20. 8	Fog.
16	21	N.	21	N. E.	20	N. E.	20. 3	
17	21	N. E.	24	Calm.	23	N. N. E.	22. 8	Snow, fog.
18	28	Calm.	26	N. N. E.	24	N. E.	26. 1	Snow.
19	19	E.	23	E. S. E.	22	E. S. E.	21. 2	Fog, covered.
20	26	S. S. E.	26	S. S. E.	27	S. E.	26. 1	Fog.
21	35	S.	33	W.	37	S. W.	34. 9	Rain, covered.
22	35	S. S. W.	37	S. S. W.	31	W. N. W.	34. 3	Covered.
23	27	N.	31	N. W.	28	W. N. W.	28. 6	Foggy.
24	27	N. N. W.	29	N.	26	N. N. E.	27. 1	
25	29	W. S. W.	31	W. N. W.	30	W.	29. 7	Covered, snow.
26	26	N. E.	26	N. E.	24	E.	25. 3	Covered, snow.
27	26	E.	29	E. N. E.	31	E.	28. 4	Covered.
28	31	S. E.	33	E. S. E.	33	E. N. E.	32. 4	Covered.
29	31	E. N. E.	32	E. N. E.	31	E. N. E.	31. 3	Fog, snow.
30	30	E. N. E	34	Calm.	38	S. S. W.	33. 8	Snow, fog.
31	32	N. E.	28	N.	27	N.	29. 1	Snow.
Monthly	mean	....	.....	....	.....	....	24. 1	

Meteorological observations at Bear Island—Continued.

Date.	8 a. m.		2 p. m.		8 p. m.		Daily mean temp.	Sky.
	Temp.	Wind.	Temp.	Wind.	Temp.	Wind.		
1866.	°		°		°		°	
June 1	27	N. W.	30	N. W.	32	S. S. W.	29. 5	Snow, fog.
2	35	S. S. W.	33	N. N. W.	34	W. N. W.	34. 3	Clear.
3	37	S. W.	38	W. S. W.	34	W.	36. 3	Rain, foggy.
4	35	S. S. W.	38	S. S. W.	35	W.	36. 3	
5	37	W. S. W.	35	W.	33	W. N. W.	34. 9	Fog.
6	24	E. N. E.	24	E. N. E.	23	N. E.	23. 9	Covered.
7	28	N. N. W.	32	N. N. W.	31	N. W.	30. 4	Covered, fog.
8	35	W. S. W.	35	Calm.	31	S. S. E.	33. 8	
9	28	S. E.	31	E. N. E.	31	E. N. E.	30. 0	Snow.
10	32	Calm.	38	N. E.	37	Calm.	35. 4	Snow, covered.
11	34	Calm.	32	E. N. E.	32	E. N. E.	32. 7	Covered.
12	35	S.	40	Calm.	38	S. S. W.	37. 8	Fog.
13	38	Calm.	39	S. S. W.	39	Calm.	38. 8	
14	34	S. E.	33	S. E.	34	E. S. E.	33. 8	Covered.
15	32	E. S. E.	31	E. S. E.	30	E. S. E.	30. 9	Fog.
16	30	E.	32	E.	33	E.	31. 6	Covered.
17	33	E. S. E.	34	E. S. E.	33	E. S. E.	33. 6	Fog.
18	33	E. S. E.	35	S. S. E.	38	S. S. E.	35. 4	Rain, covered.
19	39	S. E.	41	S. E.	42	S.	40. 8	Clear, covered.
Monthly mean							33. 6	

II.

THE SCIENTIFIC RESULTS OF THE FIRST GERMAN NORTH POLAR EXPEDITION—1868.

A DISCOURSE

DELIVERED BEFORE THE SOCIETY OF ARTS AND SCIENCES OF HAMBURG, DECEMBER 1868,

BY

DR. W. VON FREEDEN,

DIRECTOR OF THE NORTH GERMAN "SEEWARTE."

EXTRACTS CONTAINING A GENERAL SKETCH OF THE EXPEDITION AND THE PASSAGES RELATING TO THE GULF STREAM.

FROM THE MITTHEILUNGEN OF THE GEOGRAPHICAL INSTITUTE OF JUSTUS PERTHES, FIFTEENTH VOLUME, 1869, PART VI.

THE SCIENTIFIC RESULTS

OF THE

FIRST GERMAN NORTH POLAR EXPEDITION IN 1868.

*   *   *

The instructions of the expedition were to penetrate as high north as possible, either along the east coast of Greenland[199] which, it was believed, might be reached with the least difficulty north of latitude 74½° N., or to attempt to reach Gillis Land,[200] from the south or around the north coast of Spitzbergen. Captain Koldewey, the commander of it, had, besides, been requested by me to make, as frequently as possible, meteorological and especially hydrothermal observations, for the exploration of the horizontal and vertical structure of the Gulf Stream, and to be careful in ascertaining the magnetic declinations in the high north, as well as along the Greenland wall.

The expedition has failed in the first and most important part of these purposes; the more valuable, however, are the results of the hydrographical and meteorological labors which, by their regularity and completeness, and the excellence of the instruments used, have not only disclosed to us new features of the oceanic and atmospheric relations in the polar regions, but have also made it possible to demonstrate in what manner and to what degree the last summer, though appearing favorable when viewed from southern latitudes, was really unfavorable for cruises in high latitudes.

The cruise consists of four attempts to push through the ice; two in the direction of Greenland and two toward Gillis Land.

The expedition left Bergen on the 24th of May, sailing north, with a fresh breeze from the south. In testing the qualities of the ship, diligent sounding and current observations were not neglected.

The first severe test of the vessel happened in a strong gale from the north on the 30th and 31st of May, which compelled the commander to heave her to, and deprived, at the same time, the expedition of the chance to view the summit of Bear Mount ,(6,448 feet high,) on Jan-Mayen, the flashing out of which from the sea of fog below it has been described so vividly by Lord Dufferin.

With redoubled energy, on account of this delay, the expedition pushed on north. The first drift wood was met on the 1st of June, and on the 4th the first drift ice—some pieces 12 feet in diameter—through which a westerly course was shaped for Greenland. But the ice soon became quite dense, so as to necessitate a very careful handling of the ship and much towing, warping, &c., until, on the 9th of June, in latitude 75° 20′ N., longitude 13° W. of Greenwich, she was completely embayed, and compelled to follow for thirteen days, helpless, the ice drift,[201] by which she was carried along the direction of the coast to latitude 73° N., longitude 16° W. There was, for two days, some sport in hunting polar bears, five of which were killed. Soundings were made wherever it was possible, as also magnetic observations, of which those obtained June 16, on a large piece of ice, were considered very good. During the same night the coast, from Pendulum Island to Hudson's "Hold with Hope," was seen from the masthead. On the 22d of June, after four days' very tiresome warping, the ship got clear of the ice, and a northerly course was taken, keeping at a distance of about three miles from the eastern limit of the ice, and looking out constantly for a passage through it, but none was found; and four ships, which were fishing there in the ice, assured the commander that, at present, it would be utterly impossible to break through to the westward.[202]

This was the end of the first attempt to reach Greenland. On the 29th of June, when in latitude 75° 10′ N., and longitude 11° 47′ W., the ship was turned to the east for Spitzbergen. On this route the water colored to constantly darker shades of blue, and rose steadily in temperature, carrying on the surface drift wood[203] and sea weed. On the 3d of July, at 11 a. m., the south point of Spitzbergen was made.

Leaving behind a flotilla of Norwegian yachts, which come here every year to hunt and fish, the easterly course was continued into the ice and between great icebergs, constantly sounding on the reef—which extends between Cape Lookout and Bear Island and is, at places, but 20 fathoms below the surface—until no bottom was obtained at 200 fathoms, showing that the extremity of the reef was reached; and the ice, nevertheless, became more and more impenetrable. A dead calm making a pressure on the ice impossible, the ship was, on the 6th of July, worked back to the west again, through the surrounding pieces of ice, which were completely covered by seal; and then, during a heavy southeasterly gale, pushed north along the western coast of Spitzbergen, until a landing was effected on the 13th in the second great fiord, the Bell Sound, at Middle Point, where water was taken in, and some excursions made to the summit of the mountains. On July 15, after leaving the fiord, the northerly course was resumed with a light breeze, past the coast of Prince Charles Foreland which showed its beautiful Alpine scenery in the bright rays of the sun, and, further on, always surrounded by grampus, whitefish, and whale playing in the sea weed; but, on the 19th, in latitude 80° 13′ N., longitude 5° 52′ E., all further progress was barred by the northern ice. The ship Jan-Mayen was met there, whose commander made favorable reports of the Greenland ice between latitudes 74° and 72°, and a second attempt there was therefore decided upon.

The ship was steered along the ice, just clear of it, through alternate green and blue bands of water, southward to about latitude 76° N., and then westward into the ice. Profiting from former experience, she now was pressed into it at once with all her power, and when not able to break through, she was directly withdrawn and another place tried. After two unsuccessful attempts, she came, on August 5, in latitude 73° 25′ N., as far as longitude 17° 22′ W., where the rocky coast of Greenland could be plainly seen about fifty miles off, a distance which could have been made in two watches, but a compact field of ice, reaching apparently to the very coast,[204] prevented her from going further. Abandoning all further attempts, the inapproachable coast was left behind on August 9, steering first east and then northeast, in order to make again for Gillis Land, this time on the northern route, around Spitzbergen and through Hinlopen Strait.

A heavy gale, the only one in which the small vessel shipped a sea, detained her some days on and below the parallel of latitude 73° N., but after that very good progress was made. On the 18th of August Moffen Island was reached; the Greenland then beat through the strait, and came to anchor in the German Bay, at Cape Torrell. In that vicinity the expedition remained until the 11th of September, changing, on account of storms, the berth of the ship frequently from one side of the southern entrance to the other, and watching whether the breaking of the ice would open a passage in the supposed direction of Gillis Land.

Throughout all this time observations were made diligently, on board and on shore, of the temperature of the air and of the sea, on its surface as well as at various depths, of the magnetic declination, of the tides, &c. An excursion was also made on shore, which disclosed two important facts; first, that King William's Island is really an island, as it had been drawn already by Scoresby, and not a peninsula, as stated by a Swedish expedition; and secondly, that the so-called Northeast Land was incorrectly laid down on the chart in its southern part, the German Bay cutting deeper into the land, and some capes, beside Cape Torrell, making out to considerable distances east of the latter.

After the ship had suffered much from the ice and lost an anchor, and as, since September 8, when the first stars were seen in this season, young ice began to form at night around the ship and in the straits, the attempt to push toward the invisible Gillis Land was abandoned as hopeless, and a last attempt made to penetrate north, on the meridian 17° E. of Greenwich.

On September 13, at 8 p. m., the ship had advanced to latitude 81° 05′ N., longitude 16° 39′ E., the highest point ever reached by a sailing vessel.[205] A gale was now brewing and the ice was setting against the ship, and as, moreover, nothing but thick ice was visible on the clear horizon toward the north, she was turned back again. At noon of the 15th she was in latitude 80° 16′ N., longitude 13° 37′ E.; on the 16th, in latitude 80° 14′ N., longitude 6° 37′ E., and as the ice was found also to bar the progress west, the return homeward was determined on; on which, to quote Lord Dufferin, she went "as if the girls at home got hold of the tow-rope." On the 30th of September the Greenland lay secure and sound in the harbor of Bergen.

If even we must acknowledge that the expedition, compared, for instance, with Scoresby, who had occasion to correct errors of longitude amounting to 14°, has but little promoted the geographical knowledge of the northern lands, the observations in general will be found the more interesting and well worthy to engage our fullest attention.[206]

The question as to the horizontal extent of the warm northeastern current, generally named the Gulf Stream, which we trace from the Straits of Bemini through the entire North Atlantic Ocean, over the comparatively high plateau between the Faroe Islands and Iceland, but far more effective in the bed depressed to a depth of 700 fathoms between the Faroe and the Shetland Islands, has been solved very satisfactorily by the route taken by the expedition. There have also been obtained significant data, from which conclusions may well be reached as to the vertical depth of that stream and the degree of the decrease of the depth toward the west, and of the alternate increase and decrease of the same toward the north.

I have been able to construct an isothermal chart of the surface of the northern sea, on which, without interpolation or the use of mean values, the equal surface temperatures, really observed at any time of the day in the various positions of the vessel, are connected by curves. In these high latitudes, where a nearly always obscured and foggy sky permits of but little insolation which, moreover, on account of the slow motion of the sun, is always very evenly distributed, the daily period, even in our latitude scarcely perceptible on the high sea, can well be neglected. The absence also of cotemporaneous observations at different places did not cause inconvenience, as the generally increasing temperatures of July could readily be combined with the decreasing of September by assuming for the mean epoch of the chart about the 10th of August. The July temperatures, however, which all were obtained in the ice off the Greenland barrier, had to be considered separately, while the first of the May and the last of the September observations permitted nearly identical conclusions to be drawn as to the horizontal and the vertical structure of the Gulf Stream.

Beginning with a surface temperature of 54°.5 (10° R.) at the end of May, off the coast of Norway, (compare note 33,) we find it soon decreasing to 41°, (4° R.,) and a comparison of the observations for the end of May, as well as of those for the end of September, shows that from longitude 3° to longitude 0° east of Greenwich this decrease amounts for each degree of latitude up to 71° N. in the average to 1°.1, (0°.5 R.,) but for each degree further west only to 0°.9, (0°.4 R.,) consequently to twice as much in a western as in a northern direction, as the arcs of longitude measure there, in length, only two-fifths of the arcs of latitude of equal angular extent. At the same time a north-northeastern drift current was observed of twelve miles on the way out, and of ten miles in returning, which, however, ceases entirely in latitude 68° N., longitude 0° 40′ W., as regards the sea west of longitude 0°, and is temporarily pushed aside by a cold southeastern counter-current, even as low as in latitude 66° N., longitude 0° 40′ W.

Further north, directly from the parallel of Jan-Mayen (71° N., that also of the North Cape) up to latitude 77° N., we find a great area of the ocean, which from June to September has a temperature fluctuating between 32° and 36°.5, is full of melting drift ice, the more so the further west, and which has, in alternate bands, of miles in width in the one; the clear deep blue color of the Gulf Stream, in the other the dirty olive-green of the glaciers and northern ice fields, originating, according to Scoresby, from the innumerable yellow infusoriæ in these bands, on which the whales, abounding there, feed. Beyond this area the isothermal lines, which so far fall pretty close together, recede to greater distances from each other in a northern direction, and only the curves of 41° (4° R.) and below retain, still north of latitude 71° N, a northern direction.

By a number of well-agreeing observations of the temperature and of the currents, the fact has been established beyond doubt that there is in July, August, and September, west of Spitzbergen, a long-stretched, narrow spur of the Gulf Stream, flowing north and of a minimum temperature of 41°, which extends to latitude 80° 10′ N. on both sides of the meridian of 8° E., bounded easterly by a narrow and cold southern coast current running along Spitzbergen, and westerly by the great general Polar Current. Beyond latitude 80° 10′ this spur, still of a velocity of twelve to fourteen miles in twenty-four hours, is in part deflected, first northeasterly and then easterly, by the polar waters rushing down from the north, until lost in the ice in about 81° N. and 15° E., and, partly, it appears to submerge below the ice and to flow as a deep-sea current directly north to unexplored regions.

The above-described extensive basin, of 36°.5 mean temperature, from Jan-Mayen to the icy barrier in latitude 77° N., and this last northern spur of the Gulf Stream of a mean temperature of 41° to 42°, evidently owe their existence to the reef between Spitzbergen and Bear Island, and to the relations of the currents and the ice proceeding from the same.

It is well known that the Gulf Stream, in consequence of its varying temperature, vibrates in its course during a yearly period, in the summer to the northward, in the winter to the southward. The fact that, on account of this vibration, the stream does not reach in winter even the southern cape of Spitzbergen, is proved indirectly by the monthly mean temperatures of Cape Lookout, which are, in November 14°, in December 5°, and in January 7°.3.[207] But on Bear Island it is possible to work at Christmas in the open air, and in Hammerfest we find at the same time the climate of St. John's, in Newfoundland, which lies 20° of latitude to the south of it, on about the same parallel as Paris and Vienna, and in January even, the climate of Halifax, in Nova Scotia, which has the same latitude as Genoa. At that time the warm stream flows between Bear Island and the North Cape in an eastern direction toward Nova Zembla.

In March and April, however, Bear Island becomes inhospitable. The western compensation current pushes the masses of ice, which part from Barents-land and further east from Nova Zembla and North Siberia, against and over the reef; a part grounds where there are only 21 to 45 fathoms of water, leaving afterward deposits of stone and moraine, of which the Germania brought home beautiful specimens,[208] and another part comes, eastward of the reef, in conflict with the Gulf Stream, flowing now in a more northern direction, and sets partially through it, carried along by the winds and the cold deep-sea current; thus considerable quantities of Spitzbergen and Siberian ice get into the Greenland Sea and unite there with the great arctic drift to the southwest, sometimes imparting to it a more western direction.[209]

That the crossing of the two streams really occurs at the place designated above, is proved conclusively by the deep-sea thermal observations.[210] It has been established beyond doubt by late investigations on the high seas, that sea water reaches its maximum density, or, in other words, its greatest gravity, in exactly the same manner as fresh water, at a temperature of 38°.7, (3° R.;) and, further, that sea water freezes to ice at a temperature of 27°.5 after secreting its salt.*

That, in consequence, a great lake, the bottom of which is not affected any more by the annual insolation, must have near the bottom a homothermal stratum of a temperature of 38°.7, down to which in the summer a gradual decrease, and in the winter a gradual increase of the temperature takes place, is a fact irrelevant for the ocean, but facilitating easy conception, as in the ocean, with its horizontal currents over unequal depths and the frequent collisions of the same when they come from different directions, there must always be a mixing of waters of different temperature.

It is further clear that when two currents meet from directly opposite directions, a lateral deflection of one or both must take place, as we just have seen in the case of the two compensation currents south and north of Bear

---

* Authorities in physical science have ascertained *fresh* water to be of maximum density at a temperature of 39°.2, but sea water at 25°.38 below its point of congelation, which is estimated to be at a temperature of 27°.4. Compare Despretz, in Miller's Elements of Chemistry. London, 1867; vol. i, p. 262.—HYDROGRAPHIC OFFICE.

Island, and those on both sides of the Spitzbergen stream; while, when they meet at right angles, the warmer stream must, under the laws of gravity, flow across *over* the colder.

The observations by the expedition confirm these theories in a very interesting manner. While in the latitude of Bergen nearly the same temperature is found in 70 fathoms of water as on the surface, the observations in the deep basin near the Arctic Circle, which has a depth of 600 fathoms, and even up to latitude 68° N. in about longitude 0°, show distinctly a decrease of the temperature of about 0°.6 for each 10 fathoms increase of depth. It would be worse than a venture to deduce from these observations a general law for all depths, if even such proves correct for a depth of 100 fathoms in latitude 68° N.;[211] but various observations of September 22, in latitude 72½° N., longitude 3½° E., save us the necessity of such assumptions. In the very region where we just conjectured a submersion, during the summer, of the Polar Stream beneath the northern branch of the Gulf Stream, our observers, without being aware in any way of such hypothesis, found the temperature of the sea to be at the surface 39°, and at a depth of 40 fathoms 37°.6, but at 60 fathoms only 32°. Thus the same stream, which 4° further north flows over a basin of a depth, according to the late Swedish soundings, of 1,350 fathoms, deep enough to sink all the mountains of the northern half of Germany,* the same stream which in latitude 80½° N., in a sea of 2,170 fathoms in depth, enough to submerge the plateau of Bern, in Switzerland,† has, at a depth of 100 fathoms, still a temperature of 37°.2—this same Gulf Stream we find, in September, a few hundred miles southwest of Spitzbergen, in a shallow bed of but 50 fathoms in depth, flowing away over the submerged Polar Stream, which there crosses its course, and which immediately after, having passed the reef which has but 20 to 50 fathoms of water over it, deepens to 700 fathoms.

Following this latter stream to Greenland, we find it soon again on the surface uniting with the great Arctic Stream which comes down around the north coast of Spitzbergen, then flowing southwestwardly with a velocity of twelve miles in twenty-four hours over an average depth of 400 fathoms, and causing on the plateau between Iceland and Greenland the habitual stoppage

* A depth exceeding the height of Mount Washington by 2,000 feet.—Hydrographic Office.

† Or, with the exception of a few peaks, all the mountains of the North American Continent.—Hydrographic Office.

of ice, which in some years makes the circumnavigation of that island a difficult, if not an impossible, task.

While, however, the stony bottom of the reef between Spitzbergen and Bear Island, and the entire absence of muddy admixtures in the numerous specimens brought home from there, prove to a certainty that the western stream reaches there to the bottom, the fine mud of the sea in the vicinity of the Greenland coast bears evidence that the common matters of sediment, as for instance the siliceous armor and the lime shells of numerous diatomeæ, polythalamiæ, &c., can settle there undisturbed, and that, therefore, the current must be but at the surface. The deep-sea temperatures also are there essentially different; on the 4th of August, in 73° 25′ N., and 17° 18′ W. of Greenwich, in 170 fathoms depth, a temperature of but 31° was found.

In closing this chapter I will yet state that the great depth of the sea north of Spitzbergen, (more than 2,000 fathoms,) the strong and regular currents there, and the entire absence of glaciers or icebergs, (ice walls or so-called hummocks of 40 feet in height, which Parry saw, cannot be considered as such,) appear to me to be indications of the non-existence of a continent or greater islands in the Arctic Sea. On this I base my conviction that an expedition for the North Pole would have the best chance of success from Walden Island, or Little Table Island, in latitude 81° N., as a basis which always can be reached in the autumn, if wintering there is prepared for and carried out so carefully that the crew, unimpaired in strength, can push north as rapidly as possible, in Parry's sleigh boats, in the spring, while the snow is still hard enough to bear the weight. Parry traveled 1,127 miles in sixty-one days, averaging twenty miles a day.[212] If, on account of a colder season, and for the absence of currents, we only count on half that speed, the return might be easily effected in the autumn. But that a steamer, even the strongest iron-clad, would be able there to press through the compact and extended fields of ice, is improbable; whether it could be done along the coast of Greenland is uncertain; at any rate there is from the part of Greenland, in about latitude 75° N., which may be reached, as also from the ice barrier north of Behring's Straits, generally in still lower latitudes, a distance doubly as long to the North Pole as that from Walden Island. If, however, the problem to be solved is the mercantile or scientific exploration of the Arctic region, then the east coast of Greenland would be preferable as a basis to the Norwegian coast. Inferences as to the chances of success may be drawn from the experience of the previous explorers.[213]

If even precaution requires that the hydrothermal relations of the ocean should not be assumed as the same for each year, we may, nevertheless, from physical reasons, attribute to them a greater constancy than to the thermal status of the air. But the analysis of the latter is, in the case before us, of higher interest, because the loosening and the melting of the ice, and consequently the success of the expedition, depended in a great measure upon the temperature of the air. As the intellectual director of the expedition founded his instructions upon the assumption that the Greenland coast in its normal status is not unfrequently, and under favorable circumstances very readily accessible, the inquiry into the actual status of the air must demonstrate that it was, at least in part, the cause of the failure, next to the uncommon winds which drove the ice together, unfavorably, between the parallels of latitude 76° and 72° N. We will see that hardly the winds, but surely the temperatures, were abnormal.

[The lecturer now goes on to demonstrate in what manner and to what degree the summer season of 1868 has been an unfavorable one for Arctic exploration, discussing the observed temperatures of the air, and comparing them with the monthly and yearly isothermal curves of normal temperature, constructed by Professor Dove. He shows that the daily mean temperature observed on board the Greenland has been for one hundred and four days lower, and only for twenty-four days higher than, or equal to the normal temperature at the respective places, while these relations had in lower latitudes the reverse character. At Hamburg, for instance, the sum of the mean temperatures for the months of June, July, August, and September, exceeded the sum of normal means by 14°, while the sum of the monthly means of the temperatures observed on board of the Greenland for the same period is less than the sum of the normal mean temperatures for that time in the respective places, and most remarkably by exactly the same amount as the above excess; the excess in the lower latitudes appears to balance the defect in the higher. The abnormally low temperatures found there naturally caused a frequent interruption of the melting of the ice and snow, the frequent and early formation of new ice, more frequent snow, and nearly constant fogs, all of which contributed to impede and finally to bar the progress of the expedition. Two temperature tables appended to the published discourse will be found in note 214.

Mr. Von Freeden then turns to the discussion of the winds, and closes with a few remarks on the magnetic observations, to which a table of the compass deviations is appended. These last two chapters are of interest to navigation, and therefore given entire as follows.—HYDROGRAPHIC OFFICE.]

As abnormal as the thermal relations of the atmosphere of the Northern Sea have been during the summer of 1868, they will not give us a complete insight into its climate during that time, if we do not consider also the winds, or what we generally call "the winds and the weather." Before doing so, I will state two very striking cases experienced by other explorers. Parry observed in latitude 82° 27′ N., longitude 20° 32′ E., on the 15th of July, 1827, after a heavy rain of twenty-one hours' duration, the temperature of the air to be: in the shade 37°.6, in the sun 47°, and at the black gunwale of the boat 72°.5, the heat melting the pitch in the seams of the boat; this was in a calm, but as soon as a faint breeze arose the thermometer fell everywhere below 40°. Scoresby records that in April 1822, when one hundred and fifty miles east of Iceland, in latitude 64° 30′ N., he was driven from his course by the ice which could only have been drifted there by continuous winds from the N. W.; and that, at the end of May, from latitude 75° N., longitude 0°, he has been in the ice, into which the Greenland came nearly at the same time of the year and on the same parallel, not until reaching the meridian 8° W. of Greenwich. I might refer also to the minimum temperature of —68°.1, observed by Hayes in 1864, which excessive cold he calls a comfortable one on account of the calm accompanying it, and which, with the slightest stir of air, rose immediately to —29°, but then made the open air painful to bear. But all these were winter temperatures, while we have to deal with the northern summer of 1868.

Calms were prevailing during that summer in the Northern Sea. Of the 773 watches of which the record was kept by the expedition, it was calm in 117; there were 83 watches with winds from the N., 65 from the N. N. W., 46 from the N. N. E., &c., (see the table of winds, note 215.) If now Parry could observe, in calm weather, so very high temperatures in latitude 82½° N., on the field ice over which he drew his sleighs through knee-deep pools of water, an energetic melting of the ice might well have been expected off Greenland, five hundred miles more to the southward.

It is, indeed, my opinion, founded upon the sum total of observations, that the quantity of ice before the coast was not greater than in other years; but it appears that, on account of the deficiency in the heat of the sun, it remained harder and firmer, and was, by the frequent northerly and easterly winds, driven together more compactly than found, for instance, by Scoresby, who met the ice drifting before westerly winds one hundred and fifty miles further to the east, but could, for that very reason, push more readily through it.

The many winds from the N. N. W. to N. E. are, however, not extraordinary. Like the slow waters of the Gulf Stream, the movable masses of the air follow everywhere the laws of gravity. The former are moved by a "*vis a tergo*," the centrifugal power, the latter by a "*vis a fronte*," the aspiration, as soon as the equilibrium is disturbed. With the same propriety as we speak in the sub-tropical regions of a N. E. or S. E. trade wind, and in the middle latitudes of a S. W. and N. W. anti-trade wind, we may distinguish in the Arctic and Antarctic regions between a north and a south trade wind inclining to the east, as the natural agglomeration of the waters toward these regions, and the normal flowing off toward the Equator must compensate each other.

The waters being heated in the equatorial regions, flow, like the masses of air, toward the Poles, and passing parts of the earth's crust, toward which they move more rapidly, from their greater participation in the earth's rotation from west to east, they appear to be deflected easterly; the northerly current is turned into a northeasterly drift stream; the upper south wind, descending nearer to the earth, on the southern side of the region of trade winds, is turned into a S. W. wind. The *usage* of the expression covers the apparent opposite but really the same direction of the movement. Thus both, turning more and more westerly, reach the southern limit of the frigid zone. But the gap created in the equatorial regions has, before that, caused a compensation movement from the Pole; the polar masses of waters and ice and those of air, the former finally as a southwesterly drift stream, the latter as N. N. E. winds, come down slowly, first in a strictly meridional direction, then apparently deflected to the west, on account of the parallels of latitude rotating eastwardly. In Europe, moreover, they are deflected laterally by the east-westerly direction of the mountain ranges; while, in America, the longitudinal valley between the Alleghanies and the Rocky Mountains permits the northern and the southern winds to pass unchecked, thus favoring the rapid and great changes in the climate. When unequal forces meet, the weaker is pushed back frontally or laterally; and when the forces are equal, an agglomeration of both takes place, showing as a calm, as indicated by the barometer. The waters of the ocean, more sluggish in their forward movement and less subject to lateral deflections, we perceive, complete their rotary courses in more constant beds, subject, however, to some changes in an annual period; but it is otherwise with the masses of air, which are doubly agitable by their expansion and the changes in the component moisture. In their struggles there are light and heavy, long prepared, and sudden attacks from either side; the northern stream of air, threatened in its very home by the southern aggressor, wards off stubbornly the charges, and assumes the offensive successfully. The phases of the conflict are reflected by the wind-vane, the barometer, and the changing form of precipitated moisture. Sometimes we see masses of air pushing forward in an equatorial direction, with more or less speed; perhaps they are a succor for the struggle south of the observer, or perhaps they rush through a region of air less expansive, on account of more violent precipitations; the unchanged vane, the steady barometer, and wet fogs mark their path. Frequently the constant change of the vane indicates that we are within the region of the struggle, and in the Arctic region we will find the Arctic relations directly reverse of those in our latitudes, by the changes of the vane in the opposite direction.

While, in our latitudes, the change of the vane goes, as a rule, with the dial of the watch or with the sun, the journal of the expedition shows that the wind changed *against* the sun in gales on fifteen occasions, and in fair weather on ten; but *with* the sun in gales only in six instances, and in fair weather also in six instances; and it is further shown by the record that the changes *against* the sun occurred in the northern as well as in the southern part of the Northern Sea, but all the changes *with* the sun only south of the parallel of latitude 75° N. What else can be indicated thereby other than that the S. W. wind can push back the Polar Stream for a length of time only south of latitude 75° N., always accompanied by pouring rains, and not north of that parallel of latitude; and, further, that throughout the frigid zone the northern wind is the more powerful one, and that the tendency of the wind to fall back against the sun to the N. to N. N. W. is caused by the closer vicinity of the western pole of cold, or the region of the least heat of the sun in North America?[216]

If permitted to illustrate this physiological review of the changes of the winds of the Northern Sea by a few statistical details, I would abstain from the use of figures, if it were not for their showing best the character of the northern weather.

We have stated, above, that calms are the most frequent; from this it might be expected that the winds would generally be light in the quiet air basin over the Northern Sea, and such is really the case. The seaman expresses the force of the wind by figures from 0 to 12, those from 0 to 8 being sailing winds, and from 8 to 12 gales. The average force of all the winds noted in the journal of the expedition, inclusive of the calms, is 3.5, exclusive of them, 4.1; the average force of all the storms being only 8.4. And still we see through the records the old experience that cold winds appear to be stronger, as they really are. In fifty-four watches storms were noted; each seventh watch is calm, each fourteenth stormy; all storms, without exception, were followed by calms. The majority of storms came suddenly and went down quickly; the greater gales, however, blew, as with us, for some days. The region of the more violent gales is the high sea; they generally blow from the eastern to northern quarters. Violent storm squalls were observed but twice, both times in the southern part of the Northern Sea. The greater heat in the summer season in the Siberian, Russian, and probably also the Greenland main, in contrast with the mild temperature of the sea, is a constant source of compensation; while the close vicinity of the Gulf Stream waters to the cold ice fields is the cause of frequent local violent explosions.[217]

Characteristic of the Northern Sea, but easily explained by the great difference in warmth and moisture between the meridians which approach each other more and more closely, is the frequency of fog and of the hard and liquid precipitations. While, in the average, of one hundred watches seventeen entire were foggy, five rainy, and in ten it was snowing; but twice a clear, blue sky was seen, against an average of 80 per cent. of covered sky; the month of June, off the coast of Greenland, was still more gloomy. The Greenland day had, in the average, eight hours of fog, so thick that nothing could be seen beyond the length of the ship, four hours of snow drift, besides some little rain, and the clear sky was not seen once in June. In a week off

Greenland there are noted forty-six hours of fog, seventy-seven hours of snow, and two hours of rain. In a September week, in Hinlopen Strait, twenty-six hours of fog, seventy-seven hours of snow, and thirty-two hours of rain. In a week of one hundred and sixty-eight hours, of which one hundred and thirty-five were as before described, the remaining thirty-three were very probably transitions from rain into snow, snow into fog, &c. From the 10th to the 13th of September an uninterrupted snow drift for sixty-two hours is recorded, with flakes so large and thick that the deck had to be cleared off every hour.

It remains only to cast a glance at the last series of observations—the magnetic. Though it is inviting, with reliable observations, to unravel the mute sayings of the magnetic needle, and to trace the power which, from parallel to parallel, from meridian to meridian, and from year to year, changes the direction of the magnetic north, I thought it best to wait for more extended and more accurate series of observations, to which those before us might be added. Magnetic observations on board ship, under the constant and varying influences of local attraction, have great difficulties in themselves, which are augmented by the inaccuracy of the instruments generally used on the high sea. If it has been admitted that, in many of the observations, errors of one-eighth of a point were unavoidable, they are still good enough for practical navigation, (we often have to use data far more incorrect,) but they cannot be entered in scientific inquiries into the earth's magnetism.[218]

It is to be hoped that new expeditions will enlarge our knowledge of the Northern Sea also in this respect, and that landings at various points of Greenland and Spitzbergen may be effected, permitting the employment of more precise apparatus.

III.

THE SYSTEM OF OCEANIC CURRENTS

IN THE

CIRCUMPOLAR BASIN OF THE NORTHERN HEMISPHERE.

BY

DR. A. MÜHRY.

FROM THE MITTHEILUNGEN OF THE GEOGRAPHICAL INSTITUTE OF JUSTUS PERTHES, THIRTEENTH VOLUME, 1867, PART II.

THE SYSTEM OF OCEANIC CURRENTS

IN THE

CIRCUMPOLAR BASIN OF THE NORTHERN HEMISPHERE.

By a careful collation, on the basis of a sound theory, of the various details obtained so far in regard to the oceanic currents of the circumpolar basin of the northern hemisphere, (or, in other words, by the rational composition of the hydrographic facts,) it will be possible to arrive at a general conception, comprehensible at least in the fundaments, of the disposition or the system of these currents, even with our present incomplete knowledge of such unsteady phenomena which represent a much complicated and difficult part of the telluric system.

§ 1.

We find, in that highest and coldest oceanic central region of our hemisphere, a constant exchange of egressing colder and ingressing warmer water in exactly equal quantities, the principal cause of which we assume to be the difference in the temperature of the equatorial and the polar waters. The streams and counter-streams, thus created, must arrange each other, not only in a horizontal, but also in a vertical distribution. The horizontal distribution, as also the general directions, are dependent on the configuration of the basin, which has a broad aperture only toward the Atlantic Ocean, and on the rotation of our globe, on account of which each stream is pushed to the right. The vertical distribution is regulated by the hydrothermal law, according to which sea water, like fresh water, attains its maximum density and gravity at a temperature of about 39°.2.[219] Of two streams meeting each other, one or the other, the colder or the warmer, will soon prove the relatively less heavy, and this will continue its course on the surface, while the heavier will submerge and flow underneath the lighter, provided that they cannot proceed side by side. It must and can be assumed that there is, at the bottom of the polar basin, really a temperature of 39°.2, or nearly so, and that there is a gradual decrease of it to the surface, where it is 28°; the lowest of flowing water, just near the point of congelation, below the floating field ice of about eight feet in thickness, which, at the top, has perhaps a temperature of —58° (—40 R.)[220]

In judging of these relations, it must be taken into consideration that there forms, in summer, on the surface, a stratum of water which contains no salt at all, or but little—the melted water of the glaciers, sea ice, and snow, which floats uppermost only on account of its lack of salt, in consequence of which it has lost in specific gravity, (in proportion about 1023 to 1028),—and that a misconception of the vertical distribution of temperature may readily be caused if there is found water, on the surface, of a temperature of 38°.8, (by insolation,) while, in not inconsiderable depths, it proves to be at 32°. This apparent reversal of the laws will never occur in winter. Drift-ice and drift-wood, however, will greatly aid in comprehending correctly this system of currents.

The conception resulting from a combination on the basis of such theory of the facts obtained is strictly applicable only to the summer, (all the many, but local or momentaneous drifts and counter-drifts, those caused by the winds for instance, &c., must, of course, also be excepted;) it is, however, not probable that the places and the directions of the permanent and fundamental currents of the ocean are essentially different in the winter, because, with the motive of the exchange, the movement must remain, even if beneath the firm ice near the coasts; that this ice also moves, at least near its edges, has been observed repeatedly, especially in Baffin's Bay, through ships which were frozen in and drifted southwardly with the current.

We now turn to the exposition of our own conception of the phenomena in motion, which, however, must be taken but as parts of a great whole, to which we shall refer first.

The great circumpolar basin, representing in its outlines pretty nearly the circumference of a circle, is bounded by the north coasts of the great continents, Asia, Europe, and America, and about the parallel of latitude 70° N., beyond which these continents reach only in some few places to 76° N., and in one to 82°; and is connected but on one side, in the northeast of the Atlantic Ocean, by a wide aperture embracing about the fifth part of the circumference, with the general mass of the oceanic waters of our planet. In this coldest oceanic central region, at the vertex of the hemisphere, (the central space of which is, however, not yet known, but may, for good reasons, be assumed to be water,) is the source (or the central point of origin and return) of the latitudinal, or that general oceanic circulation which supplies, between the Pole and the Equator as the extreme ends, or between the center and the circumference, an exchange based upon the differences of temperature, or, which is the same, upon the differences of gravity as the motor, and which might be named thermal circulation. The opposite extreme region of exchange, the warmest of the ocean, is in the vicinity of the equatorial belt, and has, in the Atlantic basin, the form of an oblique triangle, with the basis toward the Caribbean Sea. In comparing the temperature relations of these two extreme regions we may adopt, as the general rule, that in the equatorial belt the temperature of the sea decreases with the increase of the depth, from 82° at the surface to 39°.2 at the depth of 7,000 feet, (the average depth is surely 20,000 to 30,000 feet;) but that in the polar basin, on the contrary, it increases from the surface downward from 28° to 39°.2,[221] (the greatest depth measured is 8,400 feet in latitude 76° N., longitude 13° E. of Greenwich.) There is consequently, at the bottom of the entire ocean, an undisturbed stratum of an even temperature of 29°.2, (the homothermal ground stratum,) representing at the same time the heaviest stratum of water; but, as at the surface of the ocean the temperature decreases also toward the Pole, that lowest stratum must, in the direction of the latter, be reached in lesser depths; that is, ascending by degrees obliquely, it must reach, finally, the surface at the isothermal curve of 3° R., (39° F.,) and thence it must, toward the north, again descend obliquely, leaving now the colder and consequently less heavy water above it. This normal process was ascertained more clearly and decisive in the less encumbered ocean of the southern hemisphere than it could be in the narrow aperture of the northern polar basin, especially by Sir James Ross, (Voyage of Discovery and Research in the Southern and Antarctic Regions, 1847.) According to this process the homothermal ground stratum should, at about the sea isothermal curve of 3° R., (39° F.,) form, as it were, an annular wall around the polar basin, separating the waters of the southern and northern latitudes, and preventing the circulation between them; but, as this circulation takes place, nevertheless, that temperature wall must be broken by still another motor as that of the difference of temperature, and this we find by considering, also, with the general system of the diffusion of the temperature, the motive power of the telluric system of the oceanic currents. In short, this general system of the oceanic currents consists of two tendencies crossing each other—a latitudinal and a longitudinal—each of which represents a circulation with two momentums, current and compensating counter-current. The latitudinal circulation results from the difference of temperature, (as explained above and assumed already by Arago, and not from the difference in saltiness, or from the differing quantity of evaporation and rain, which cannot supply a circulation, at least a permanent one.) The longitudinal circulation consists of the broad rotation current which proceeds along the Equator toward the west or the equatorial current, (a discovery of Columbus,) with an anti-rotation current, as a necessary compensation, flowing back again on each side of it in higher latitudes; its motor is, aided by the trade-winds, the rotation of the planet, and especially, as must irrefutably be deduced from the phenomena, the centrifugal power, directly or indirectly. The broad mass of water, some thousand feet in depth, which at all times is driven westwardly, not only along the Equator, but also throughout the belts of calms, (where the trade-winds cannot be the motor,) requires at its fountain a strong compensation, for which also a part of the waters of the higher latitudes, inclusive of those of the polar basin, are drawn down. (The process is more distinctly represented in the southern hemisphere by the Antarctic currents on the west side of each of the three great continents.) By these waters the intervening temperature wall, the crown of the homothermal ground stratum, must be torn, and thus the circulation between the extreme waters, differing in temperature and gravity, is effected and maintained.[222]

§ 2.

If we now confine ourselves to our more narrow limits, we find in the aperture of the circumpolar basin the two momentums, of which the circulation consists, the egressive and the ingressive, more close to each other, but still separated by Greenland. The entire circulation must be distinguished as an eastern and a western part, each of which consists of an outflowing, colder polar stream, and a sufficiently compensating, inflowing, warmer anti-polar current. What we see of them in the aperture of the basin, (we may embrace it by naming it a channel, extending along both coasts of Greenland from the south point to latitude 70°, and even 80°,) however, are but the first stages of the outflowing polar, and nearly the last of the inflowing anti-polar currents; because both these, the first soon after its egress, the other soon after its ingress, disappear from the surface, immersing and proceeding as submarine currents, when and where, in consequence of their temperature relations, they become heavier than the waters before them.

There are, therefore, to be distinguished:

I. The outflowing momentum, or the Polar Current. 1. The eastern branch. 2. The western branch.

II. The inflowing momentum, or the Anti-polar Current; that is, the northern extension of the Gulf Stream. 1. The eastern branch. 2. The western branch.

III. A problematical current along the middle line containing both momentums.

§ 3.

I.—THE OUTFLOWING MOMENTUM, OR THE POLAR CURRENT.

Looking upon the circumpolar basin from above, that is, in its polar projection, in order to combine the various statements of the polar explorers in regard to the currents, the drift-wood, and the drift-ice, it will be discovered that there is an egressive momentum in two branches. It is not only explicable, but may also be seen clearly from established facts, that streams, some degrees of longitude in width, extend from about Behring's Straits to the eastward and to the westward, along the coasts of the basin, seeking an outlet into the Atlantic Ocean, which is only possible between America and Europe, where there is a channel by the aperture, in width about the fifth part of the circumference of the basin; while the Behring's Straits are so narrow and so shallow that they can hardly be considered at all as an ingress or an egress of the waters of the ocean, although an inflowing surface stream and an outflowing under-current have been observed there, at least in the summer.

1. *The Eastern Polar or Arctic Stream.*—This branch is especially called the Arctic Stream, because it was for a long time the only one known. It is not at all doubtful that a westerly current flows along the entire north coast of Siberia, from the easternmost part of it. Such a current has been observed and is reported from the mouth of the Kolyma to the mouth of the Lena. F. Von Wrangell, during his remarkable three years' stay at Nishne Kolymsk, (latitude 70° N., longitude 160° E.,) and in his travels on the ice, (compare his narrative of a voyage along the north coast of Siberia, 1839,) found that a firm border of ice forms in the winter along the entire coast of the

great continent, to a distance of about one hundred miles, which, in the warmer season, parts from the land, and, broken into fields and flakes, drifts toward the west, receiving on the way also the ice and the drift-wood of the rivers which empty there into the basin. It is remarkable that, although the south side of New Siberia consists, so to speak, of drift-wood intermixed with ice, a sea free from ice has been found to the north of it, (compare Hedenström, in Erman's Archive for the knowledge of Russia, 1865.) In the winter the current is said to flow here, in the extreme east, on the contrary, to the east, which is confirmed by Wrangell. It is possible that, from some cause, the other half of the polar egressive current, which, looked upon from the Atlantic Ocean, must be called the western half, begins its course even some distance west of Behring's Straits; but such is still doubtful, and it is difficult to inquire into it, on account of the ice which covers the sea in winter. In the summer, however, an error in this respect is the less possible, as there are no tides in this region; a deception can be caused only through the winds.

In tracing the eastern Polar Stream in its further course toward the west, there are no records of it off the Taimyr coast, but we find it again on the east coast of Nova Zembla, which island must naturally be an obstacle to its progress; the waters are checked there, the ice and drift-wood are packed so as to form, as Von Baer expresses it, "an ice-house even in summer," which is proved, in comparison with the western side of the island, to be such, by the always low temperature and the consequent complete absence of vegetation, reported by all the Russian navigators and explorers of the Kara Straits, and Matotchskin Schar or Matthew's Straits, (Pachtussow, Zinolka, Von Baer, and others.) But the stream must proceed in order to find an egress from the basin; it goes around the north coast of the island, in latitude 76° N., where the Dutch explorer, Barents, suffered from it: in trying from the west to round the north point, his ship was, by the ice flakes pressing against her, lifted, like drift-wood, completely out of the water and hurled on the low east coast of the island, where the wreck perhaps may be seen still. Von Lütke, at a later date, found the northern part of the west coast comparatively free of ice, (more so than the southern part of the same coast and the northern coast of Russia,) but on the parallel of the north point he met the southern border of apparently thick ice, (compare H. Berghaus, Hertha, "Zeitschrift für Erdkunde," 1825;) this, doubtless, was the southern border of the ice stream, our eastern Polar Stream. The latter does not proceed from there to the south, directly for the outlet from the basin, but strangely keeps on its western course, and even more northwesterly, until reaching the east coast of Spitzbergen, whence it turns to the north and around the northern coast of this group. It cannot but strike the observer as remarkable that it takes this longer route, instead of following the direct line to the outlet, along the west coast of Norway. There must be an obstacle preventing the latter, and such really exists; it is the broadly inflowing current, the main branch of the anti-polar counter-current, that is, the Gulf Stream, proceeding northeast to about latitude 74° or 76° N., when, submerging beneath the Polar Stream, which still flows in a vertical direction to that of the other, it ceases to be an obstacle. The Polar Stream shows its presence on the east and the north coasts of Spitzbergen (latitude 80° N.) very decidedly, by the accumulation there of ice and drift-wood, the latter exclusively on the east coast, and nearly all pine. In regard to the packed ice it is stated by whalers (compare Barrington, "The Possibility of Approaching the North Pole," 1828) that, in several years, vessels have sailed around the north-east coast of Spitzbergen, but such is but exceptionally practicable.

From the northwest point of Spitzbergen the stream proceeds south-west, finding finally a free egress; it touches the east coast of Greenland, but the northern part of this coast, at and beyond latitude 75° N., remains free from it;[223] the stream cannot accordingly have a great width, which fact is corroborated north of Spitzbergen by Parry, who had nearly reached the northern limit of it in latitude 82° 44′ N., and also at the south cape of Greenland, where it has been found to be about eighty nautical miles broad, and the ice more dense and consequently more difficult to be broken through. Its velocity, from latitude 76° N. to Cape Farewell, has been found, by whale ships embayed in the ice, to be twelve nautical miles in twenty-four hours, which is corroborated by Graah and Scoresby, (the same velocity as that of the western Polar Stream in Davis' Straits, the so-called Labrador Stream.) With its southern, or now southeastern edge, the stream touches Jan-Mayen and the northwest point of Iceland. In its course along the east coast of Greenland it also receives ice flakes and even icebergs, and is there quite narrow, until some degrees south of Cape Farewell, but not more south than latitude 58° N., and not more east than 41° W. of Greenwich, it disappears from the surface. The cause of this disappearance is, in our opinion, a conflict there with a considerably higher tempered branch of the Gulf Stream, (the temperature relations being about 32° to 48°,) flowing as a compensation anti-polar counter-current to the north into Davis' Straits and along the west coast of Greenland, in consequence of which conflict the Polar Stream, as the heavier water, sinks beneath the other, and proceeds thence as a deep-sea current, probably to the intertropical region. This conception, however, differs from the generally adopted one, which is that the current running along the west coast of Greenland is this very Polar Stream, which, after flowing along the east coast and arriving at the south point of Greenland, turns around that point and proceeds north. This is against all theory, because, if inquiry into the motive is made, none will be found; facts also point to a different arrangement of these phenomena. These facts are most excellently stated by Irminger, (in the Journal of the Royal Geographical Society for 1856, and before that in the "Zeitschrift für Allg. Erdkunde, 1853 and 1854, and lately in 1861;) but they have not been properly applied in forming the theory of currents; the two entirely different streams have never been distinguished.[224] When discussing the western Anti-polar Stream, (in section 6,) we shall take up again this question.

§ 4.

2. *The Western Polar or Arctic Stream.*—This current, with its masses of ice, among which are the greatest icebergs of the northern hemisphere, is well known as the "Labrador Stream" on the western side of Davis' Straits and Baffin's Bay; but it may readily be traced much further back to its source. As far back as north of Behring's Straits the principal current is an easterly one, and also on the west side of the westernmost and greatest islands of the Parry Archipelago, Bank's Island, and Prince Patrick Island, the tendency of the Polar Stream to an easterly course is unmistakable, and sometimes even very distinct, quite as much as the easterly current is on the east side of Nova Zembla and Spitzbergen. Not only on the west side of Bank's Island is the sea from the Siberian coast covered by impenetrable masses of ice, as has been experienced by Cook, Kellett, Rodgers, and, in the immediate vicinity of that island, by Collinson and McClure, who saw it there packed in terraces; but also drift-wood, partly petrified and carbonized, is piled up on the west coast of the island in such great quantities that that coast may be said to consist mostly of wood. (Compare Alex. Armstrong, Northwest Passage, &c., 1857, p. 395.) Similar facts were

found by the sleigh parties of Belcher's Polar Expedition on the west coast of Prince Patrick Island, and on the southwest coast of Melville Island; and finally we have, in addition, the distinct statement of McClure, who remained for two winters in that region, that there is on the west side of Bank's Island a constant motion of the sea toward the east. (Compare McDougal, the Eventful Voyage, &c., of the Ship Resolute, 1857, p. 141.)

There is, further, no doubt of the existence of an easterly current within the Parry Archipelago, the field of so many explorations and winter stoppages, although the flood tide sets there to the west; and we can trace its course uninterruptedly from Melville Bay through Barrow Straits and Lancaster Sound, then southerly along the west coast of Baffin's Bay and Davis' Strait, always covered with thick ice,[225] past Hudson Bay, from which ice is still added, and along the coast of Labrador, until finally at Newfoundland, or more accurately at the great bank on the east side of Newfoundland; this Polar Stream, or, as termed in the last part of its course, the Labrador Stream, (the velocity of which is said to be twelve nautical miles per day,) disappears from the surface, sinking below the warmer waters of the Gulf Stream, which flows here toward the northeast; only a small part of it proceeds uncovered, close to the American coast in a southwest direction to the south point of Florida; the principal part flows as a deep-sea current through the Atlantic Ocean to the equatorial region. (Compare J. Kohl, in the "Zeitschrift für Allg. Erdkunde," vol. xi, 1861.)

The well known thick fogs of the vicinity of Newfoundland bear evidence of the great difference of temperature of the two streams, (the Gulf Stream has there, according to Maury, about 59°) a contrast, perhaps, nowhere else to be found. The Polar Stream, when submerging, must naturally leave its icebergs on the surface; these, however, do not drift with the Gulf Stream, in a northeasterly direction back to the polar basin; on the contrary, they keep on in their former course toward the south, and prove thus the continued progressing of the now submarine western Polar Stream in that direction, and at the same time the shallowness or the inconsiderable depth of the Gulf Stream, which may also be concluded from its fan-like expansion.

Only few icebergs are found in the eastern parts of this region; according to Rennell they never cross the meridian of 46° W. of Greenwich, (that of Cape Farewell.) It was considered a very extraordinary phenomenon when James Ross met two great icebergs in latitude 61° N., longitude 6° W.

From the fact that they never go south of the parallel of latitude 41° N., it would follow that they melt very rapidly, which may be attributed partly to the high temperature of the Gulf Stream, and partly to the inconsiderable cold of the icebergs themselves, which, because saturated with water while they were glaciers, keep at least at their core at a temperature of 32°.

A very remarkable evidence of the course of the western Polar Stream through the American Polar Archipelago, as traced above, is borne out by the fact that in different years four ships beset by ice, and therefore unmanageable, (those of Ross, De Haven, and McClintock, and the abandoned Resolute,) drifted the very same course through the center of the Parry Archipelago to Davis' Straits.

It is very probable that the cold stream which rises to the surface on the northwest coast of Africa is a continuation of this western Polar Current, serving as a compensation for the rotation current and reaching to the Guinea coast.

We now must turn still higher north to see whether this western Polar Stream exists, and has been found also along the north coasts of the Parry Islands, (latitude 77° N.,) to where the celebrated sleigh expeditions of Belcher, Richards, Osborn, Hamilton, Mecham, McClintock, Penny, Sutherland, &c., have penetrated. It can readily be seen from the various reports that it exists there, but also that it is much more inconsiderable than further south, and carries much less ice and drift-wood along, deposits of which, however, are found on the northwestern coasts, entirely in consonance with the theory. (Compare the paper of Dr. Petermann, in the "Geographische Mittheilungen" of 1855, pp. 98 *et seq.*: "The discoveries in the Arctic Archipelago, from documents of the British Parliament and the Admiralty.") Among other facts it is stated there that "between Grinnell Land and North Cornwall Island (latitude 77° N.) very thick ice was encountered, and that it had packed to the height of 40 feet on the western sides of the islands;" then again: "The drift-wood consisted of but few small pieces, probably American larch-fir, originally from the Mackenzie River, and drifted around the north coast of Prince Patrick Island;" and lastly: "There was far more drift-wood on the northwest coast of Prince Patrick Island than anywhere else on the polar coasts of the entire Parry Archipelago."

It must yet be noticed that also in the Kennedy Channel, which as a continuation of Smith's Sound lies in a north and south direction; a permanent southerly current has been observed on the western side, however without drift-wood and drift ice, while on the eastern side another current was flowing in the opposite direction. This is reported by Morton, a reliable sailor of Kane's expedition.

§ 5.

II. THE INFLOWING MOMENTUM, OR THE ANTI-POLAR CURRENT, (THE GULF STREAM.)

This warmer compensation counter-current we can distinguish only in the channel-like aperture of the basin, but we cannot follow it into the basin itself, even if this should be accessible throughout, as the last spurs of the Gulf Stream, which form it, submerge below the surface, either before or soon after entering the basin, thenceforth fulfilling their purposes of compensation as submarine currents. As coming from the Atlantic Ocean, the inflowing current is generally called the northeastern branch of the Gulf Stream; it is in fact but the warmer compensation current for the cold central region at the Pole in the latitudinal or thermal circulation; while the other, the southeastern branch, represents the compensation in the longitudinal or rotation circulation, the primary momentum of which flows along the Equator in a westerly direction. In this manner the entire Gulf Stream is considered to be a double compensation current, which surely is a correct conception.

There must, corresponding to the outflowing waters, be also two branches of the inflowing current distinguished—an eastern one, the greater by far, and a western, weaker one.

1. *The Eastern Anti-polar Stream, (the Scandinavian part of the Gulf Stream.)*—It is most remarkable how the Gulf Stream, though so narrow after its exit from the Gulf of Mexico, through the Straits of Bemini, along the coast of Florida, (but ninety-six miles in width, 2,000 feet in depth, of an average temperature of 86°, and with a velocity of four miles per hour,) expands on its further course toward the northeast, (which direction it must take on account, as well of the situation and the form of the aperture of the polar basin, as of the earth's rotation,) fan-like and fluctuating, "similar to a streamer," shallowing more and more and getting slower in proportion. Its northern extent, excepting the branch which parts first from the main and flows into Davis' Strait, reaches from the southwest coast of Iceland to the west coast of Norway. There is, besides, a western branch, flowing along the west coast of Iceland, (compare Irminger's account of it in the

"Zeitschrift für Allgemeine Erdkunde, 1854, p. 183, Ocean Currents,) and this, the Iceland part of the Gulf Stream, reaches as high as the northwest point of the island, in about latitude 66° N., as proved unmistakably, not only by the drift of the water, but also by the higher temperature of the sea at this point, viz, 48°.9; while, on the southwest coast, the annual mean is only 41°.9, rising, in the summer, to 51°.6. Sartorius Von Waltershausen also testifies (in his Physical and Geographical Sketches of Iceland, 1847) to the Gulf Stream reaching the south and the west side of Iceland; and O. Torrell (Geographische Mittheilungen, 1861) says that the few pieces of drift-wood which he found on the south coast of Iceland were mostly mahogany; that on the north coast, however, the greater part was pine-wood.

From the south coast of Iceland the main branch of the Gulf Stream,[226] now extending over the entire distance from Iceland to Norway, flows slowly to the northeast into the Arctic basin up to the parallels of latitude 74° and 75 N., or about that of Bear Island. Vessels pushing north through this region, according to all accounts, never meet drift ice there in the spring; whalers say that the southern edge of the pack ice is generally reached in latitude 74° N., and that there is no difficulty in any season in reaching thus high; this, however, does not refer to the east coast of Iceland. Löwenörn (in his Description of the Coasts and Seas of Iceland, page 3) says in regard to that: "The (polar current, along the north coast of Iceland, sets distinctly to the east; drift-wood and drift ice are found more on the western and northwestern sides of the tongues of land jutting out from the main, as, for instance, at Langenae's, &c.; thence they drift northeast toward and into the main Polar Stream." (Compare also Irminger, "The Currents and the Drift Ice at Iceland," in the Zeitschrift für Allg. Erdkunde for 1861, where, on an accompanying chart, valuable observations of the temperature of the sea will be found.)* That along the line separating two streams whirlpools occur, is natural, and they may be expected also at other places. To complete the account, it must be stated that polar drift ice has sometimes been found also on the east and northeast coast of Iceland; icebergs even have come around the southeast point as far west as Westmannö, again a proof of a lateral counter-current. There are, in general, along great currents small counter-currents, created by the former, especially in the vicinity of coasts.

It is well known that nothing exists on the north coast of Norway, (in latitude 71° N.,) and to about the middle of Lapland, (longitude 35° E. of

* Irminger's Memoir will be found in Note 30.

Greenwich,) of the nature of that broad belt of ice which, in other places, girds the polar coasts of the great continents all around the basin; but immediately to the east of that meridian it is found again, beginning at the southeastern extremity of the inflowing warm current, about north of Archangel. Already Leopold Von Buch (in his Narrative of a voyage in Norway and Lapland, 1810) states that the north coast of Norway is free of Siberian ice even in winter, and that ice islands are seen on the far horizon first when eighty or one hundred and twenty miles north of the North Cape.

In following the Scandinavian branch of the Gulf Stream in its further course to the northeast and north, its conflict with the cold outflowing stream, which comes down upon it after turning around Nova Zembla, will be the next point of interest. At first sight it would appear that the Polar Stream, after having passed the head of Nova Zembla, might simply take the shortest route for the now open aperture of the basin, to the east of the inflowing Gulf Stream. That such is not the case is very probably caused by the earth's rotation, in consequence of which both the two streams which flow toward each other are pushed to their right, and, as they now meet under a very obtuse angle, a lateral giving way is impossible; therefore, and because they differ greatly in temperature, their relation of gravity must exert its influence and decide for the vertical arrangement which now takes place.[227] According to hydrothermal laws the warmer Gulf Stream must, in this case, be the heavier, as it now must be cooled down to the temperature of the maximum density of water, (sea water included, as according to experience the presence of salt does not change the law in this regard,) that is, to 39°.2, while to the uncongelated parts of the colder Polar Stream no higher temperature can be attributed than between 34° and 28°, (the latter temperature, as well known, being the lowest at which sea water can remain liquid, that is nearest to congelation and expansion to ice, and therefore found in winter just below the ice as the temperature of the uppermost stratum, if this is not water without salt.) We have a good knowledge of the temperature of the Gulf Stream in this very region, between Scandinavia and Spitzbergen, and the hydrothermal investigations have, in fact, proved the temperature there to be as surmised above. The French Scientific Commission (compare Gaimard, Voyage Scientifique de la Commission du Nord, &c., 1838,) of which Bravais, Martins, Liliêhöök, Siljenström, Lottin, &c., were members, found there, between latitudes 74° and 77° N., the temperature of the sea, in the summer, to be in the mean 38°.7, that of the air being 36°.5.[228] There is hardly any doubt that this inflowing warmer stream, the Gulf Stream, in the conflict spoken of above, proves to be the heavier water, and submerges below the surface between Nova Zembla and Spitzbergen, in the summer in about latitude 76° N., in the winter, perhaps, in about 74° N.; while the outflowing colder stream, coming from the east, as the lighter of the two, proceeds on its course with its drift ice and drift-wood over the other. How else could the inflowing stream disappear so quietly? And there is also no doubt that the latter continues on *its* course as a deep-sea current for compensation within the circumpolar basin, in which there is a motive and sufficient room for its great volume of water.

There is, perhaps, even very probably, also on the west coast of Spitzbergen, a lateral branch of the great inflowing current, the Spitzbergen branch of the Gulf Stream. A number of authorities assume this to be a fact; for instance, at latest dates, Malmgrén. (Compare the Swedish Expedition to Spitzbergen in the Geographische Mittheilungen, 1863, number xi.)[230] The western side of Spitzbergen is surely much more free of drift ice and drift-wood than the eastern, and can be reached in all seasons up to latitudes 75° and 76° N., although northwest and west winds must cause ice to be carried there.

§ 6.

The Western Anti-polar Stream, the Greenland Branch of the Gulf Stream.—The theory requires that there should also exist an anti-polar warm counter current corresponding to the western branch of the polar outflowing waters, which first is perceptible on the western side of Davis' Strait, and is generally called "West Stream." This compensation stream is, according to our conception, the stream flowing northward on the eastern side of Davis' Strait, along the western coast of the southernmost part of Greenland, remaining, however, only for a short distance on the surface, a branch of the Gulf Stream.

This conception is not that commonly adopted, and, recurring to this question, already alluded to on a previous page, we shall now state facts in support of it, or rather give to existing facts the interpretation pointing to our views, in opposition to the generally adopted assumption that the warm stream of the western coast of Greenland is a continuation of the cold Arctic

Stream which, coming down southward along the eastern coast, is made to turn around the southern point, thence suddenly to proceed north, without any evident motive. In fact, this course would be against its motive, which is a primary attraction, located in the far south. The case is analogous to the remarkable current relations on the Agulhas Bank at the southern end of Africa, differing only as much as the warm (the Mozambique) stream flows on the east coast, and upward, while the cold stream proceeds along the west coast and downward. Foggy and stormy weather is also frequent on the south end of Greenland, but the correct conception of the currents there is, after all, more difficult on account of an additional element, the drift ice and the drift-wood, which really drift around the south point, and to the west coast. A more thorough inquiry into the case, however, will soon show that, when a stream submerges beneath another one, the ice and wood swimming upon the former must necessarily be transferred to the surface of the latter, and henceforth proceed in the latter's direction. Especial testimony for our conception, that the northerly current along the west coast of Southern Greenland is a branch of the Gulf Stream, will be found in its direction, its higher temperature, and the tropical drift-wood carried by it.

This direction Irminger corroborates, inasmuch as he proves in the memoir cited above that there is no connecting current running from Cape Farewell southwesterly to Newfoundland. John Ross and W. Parry have really established, by observations south, southwest, and west of Cape Farewell, that a current flows there northwest; and Graah comes to the same conclusion from the higher temperature of the sea water in the entrance to Davis' Strait, where he observed 41°. (Compare Journal of the Royal Geographical Society, 1856, p. 42.)

For the higher temperature of this current, although it must naturally be cooled down in some degree at the surface by the ice swimming on it, we have climatic and meteorological proofs. In the first instance it follows from the extremely mild climate of this western coast between the cold climate of the eastern coast on one, and the equally cold climate of the coast of Labrador on the other side. N. Egede, still the best witness, says in this respect, (Natural History of Greenland, 1740,) "A most beautiful bay is situated between latitudes 60° and 61° N.; birch trees of 18 feet in height grow there as well as grass; although barley does not ripen, turnips and cabbage thrive well; beyond the parallel of 65° grass even does not grow." Just so far the warm stream in question reaches; there it disappears from the surface, submerging like all other anti-polar branches of the Gulf Stream at about 38°.8, which is proved, in addition, by the fact that also drift-wood and drift ice only reach as high north. The warmer climate is also proved by meteorological observations at various places; at Lichtenau, (latitude 60° N., longitude 46° W.,) for instance, the mean temperature of the year is not lower than 33°.8, and of the winter than 21°.9; that of the summer, however, is only 43°. Of the temperature of the sea in the stream itself we have only few, but still corroborating statements; about 3° of latitude south-east of Cape Farewell the sea showed in the beginning of May on the surface 46°.2, and at depths of 600 to 1,200 feet still 44°.4, (according to Graah.) We have already stated that in the entrance to Davis' Strait, between the drift ice, 41° was found by Graah. Rink (Gröenland Geographisk Beskrewet, 1857, in the "Zeitschrift für Allgemeine Erdkunde," 1857) makes the valuable statement that here, outside of the islands, the sea never freezes, and that at times pieces of ice are lifted upon the land about 12 feet in thickness, and of the form of a table with a leaf and a smaller foot; the leaf evidently had been above the water and melted less quickly, from which it may be argued that these ice pieces had drifted into warmer water.

There are, lastly, also accounts of tropical pieces among the drift-wood in this stream, such as are found in the Gulf Stream. More detailed accounts of the drift-wood in this stream are given by Dav. Cranz, (Historie von Grönland, 1770;) according to them most of it is pine and cedar; also larch-tree and asp. Irminger ("On Oceanic Currents," in the Zeitschrift für Allgemeine Erdkunde, 1854, p. 187; compare, also, Gumprecht "On Drift-Wood," &c., in the same periodical, p. 409) mentions that various kinds of mimosæ are thrown on the coasts of Norway, the Faroe Islands, Iceland, and *also of Greenland;* and in the already cited memoir of Irminger, published in the Journal of the Royal Geographical Society for 1856, it is stated, in a foot-note by the editor, N. Shaw, that, in Holsteenborg, (latitude 67° N.,) a mahogany plank, found at Disco, (latitude 70° N.,) had been worked into a table for the governor.

The end of this western inflowing warm anti-polar current is, as might be expected, the same as that of the other branches; it disappears from the surface and becomes submarine; this occurs as soon as the temperature cools down to about 38°.8, generally in about latitude 65° N., fluctuating, however, in some degree in the various seasons, as supposed and apparently confirmed. It will be well to inquire more thoroughly into the manner and the place of this disappearance, in which again the ice will aid. Cranz already states that the drift ice and the drift-wood are carried, in latitude 65° N., by a counter-current to the American coast. Irminger says, in this respect, that the stream proceeds northward, along the southwest coast of Greenland, to about latitude 64° N., sometimes even to Holsteenborg, latitude 67° N., and then, turning westward, doubtless unites with the stream which comes downward, carrying along enormous masses of ice. Rink discusses the question more fully; according to him, the drift ice appears on the southwest coast of Greenland, generally from February to June, but there is, in the autumn, a second installment; in the height of summer, (July and August,) and in winter, there is none. In regard to the disappearance of the current in the north, he assumes that the northern spur of this tongue of drift ice, which, from latitude 62° N., has, in the average, a width of only twenty to twenty-four miles, after proceeding slowly to about 67° N., diffuses there into the sea toward the west. These statements may well be brought into accord with the conception that also this branch of the Gulf Stream becomes a submarine one; the ice, the greater part of which will have melted, must then be transferred to the colder and, in this case, lighter water; and because this cannot proceed in the direction diametrically opposite to that of the southern stream, but must turn aside, it is drawn to the western side of the strait, where the Labrador Stream flows southward. There is also the rare chance here to trace the submarine continuation of the inflowing warmer stream beneath the colder water further north—a fact, though doubted by many, not improbable in itself, and in full accord with the laws for the hydrothermal changes with the density of the sea water, (which laws, together with the theory of the vertical arrangement of oceanic currents, find just here their clearest proofs,) and which fact, in this case, is but a counterpart of the much better known submarine continuation southward of the outflowing cold Polar Stream, athwart and beneath the Gulf Stream, whereby so numerous icebergs drift southward, especially in May. Such testimony for a submarine current in the opposite direction to that of the surface water is also found in Davis' Straits by the icebergs, which, immersed some hundred feet[229] and following the under current, drift northward against the surface current, and also against the wind. For this fact there are trusty witnesses, for instance, Kane, De

Haven, Griffin, Duncan, and others; (compare M. Somerville, Physical Geography, 1858, p. 219.) It is very probable, even doubtless, that this inflowing anti-polar compensation stream, corresponding to the outflowing stream, continues submarine through Baffin's Bay, and thence, perhaps, one branch through Smith Sound to the center of the basin, and another, possibly the only one, through Lancaster Sound, Barrow Strait, Bank's Strait to the region of Behring's Straits, where, as stated in the beginning, the source of the Polar Stream must be looked for.

There is only yet to be ascertained where its original separation from the Gulf Stream takes place; this is pointed out by the fact that within the Gulf Stream icebergs do not proceed further to the east than to about longitude 43° to 46°; there they probably find that bar.

§ 7.

III. THE PROBLEMATICAL CURRENT ALONG THE CENTRAL LINE OF THE POLAR BASIN.

To complete the inquiry into the arrangement of the inflowing and outflowing currents of the circumpolar basin, there is yet the status of the waters within the interior of it to be discussed.

We have thus far been able to establish through facts that an outflowing current proceeds along the periphery of the basin to both sides, the east and the west, from Behring's Straits to the aperture, which current floats down in the summer the ice bordering the coasts in the winter, and parting then from the latter, thus creates a constantly moving belt of pack ice, which sometimes contains great fields of ice, and in places also icebergs. This belt has formerly been considered a general coat of ice extending to the Pole, (Scoresby, Buchan, Belcher, Lütke, &c.;) but in all the investigations at various places, all around the basin, the polar edge of this ice has been found at the distance of two to three degrees of latitude from the coast. From this statement, however, it must not be inferred that the polar outflowing current along the coasts is only of that width; we have, on the contrary, traced it to the north coast of the Parry Archipelago, (latitude 77° N.,) where the belt of pack ice hardly shows its polar limit. That oceanic currents expand where there is room, and again that they contract where they are pressed, and, as a consequence, respectively shallow or deepen, may be seen, especially, in the course of the Gulf Stream; but the narrow bed of the eastern Polar Stream, along the east coast of Greenland, is remarkable.

From such a retrospect the question must arise, whether there is not any indication of an outflowing tendency along the middle line of the basin; that is, from about Behring's Straits across the Pole to the aperture above the Atlantic Ocean. If the center of the basin is not occupied by a great agglomeration of land, such current may well be expected, and would accord with the theory of hydrodynamics, as may readily be seen simply by emptying a saucer. It remains, however, to be ascertained whether there are facts from which it may be inferred.

Before all, the inflowing compensation current points to it, as well by its great width, (the entire space between the west coast of Iceland and the northwest coast of Norway,) as also by its direction, which is for the greater part directly toward the north. As to direct indications of the diametrical current coming from the north, if it exists, such can only be looked for above the aperture of the basin, in the so-called Greenland Sea north of Spitzbergen, and there only beyond the eastern Polar Stream which flows from the east to the west and southwest. Observations, in this respect, and statements would only be found in the records of Scoresby, Parry, Clavering, and those of whalers collected by Barrington. On the coasts of the Asiatic and American Continent, however, the current in question could appear only respectively as an eastern or a western one. In regard to the latter we have seen, on the north coast of the Parry Archipelago, not only indications of a weak easterly and southeasterly current, but also decided climatic signs of a sea toward the north free of ice, admitting, in the summer, of animal life and vegetation, and this in latitude 77° N. We do not know of observations beyond the polar limit of the belt of pack ice north of Siberia, except on New Siberia, (latitude 76° N.,) but the north coasts of this island are not known well enough for our question.

In regard to the region north of the aperture of the basin there is, first, W. Scoresby,[231] who, however, never came beyond the northern limit of the ice-belt; he says, (in his classic book, Account of the Arctic Regions, Edinburgh, 1820,) "It is possible that the icebergs found in the sea between Greenland and Spitzbergen may come from the Pole," (from which the assumption by him of a current coming from there might be inferred;) and then again: "A part of the current coming from the east, and carrying broken fields of ice, has its source also at the Pole." Parry found directly north of Spitzbergen, from latitude 81° to 82° 44′ N., on the meridian 20° E. of Greenwich, that the higher he came north, the more broken and weak became the ice; the expected unbroken and firm ice would not appear, but the ice moved constantly southward, although the wind blew from the south. Clavering's experience on the northeast coast of Greenland (latitude 75° 12′ N.) testifies, at least, to the absence of a strong current there, from which it may be inferred as probable, not only that the current has found its polar limit before reaching so far, but also that a current coming from the north is not entirely wanting there. Whalers, lastly, state that there is an open sea in latitude 78° N. beyond Greenland; that the ice opens there with northwesterly winds; that winds, currents, and ice are very variable there; that there is no drift-wood in the far north, and that (as also Scoresby said) a part of the ice drifting from east to west comes from the Pole.

We may, therefore, well say that indications of a current from the north are not wanting there, even if no one has thus far penetrated high enough to investigate it directly. If existing, it must be received by the Polar Stream which runs across the aperture of the polar basin in a curve ascending beyond Spitzbergen, and which hides it from the south. All these indications point also to the correctness of the general assumption of the *oceanity* of the inner basin, or the absence of land there, which does not preclude the existence of isolated islands and rocks inferred from the ice coming from there, and from the birds of passage going there.

§ 8.

Herewith we conclude our attempt to delineate a conception of the currents of the polar basin of the northern hemisphere, which will be in accord with the facts thus far established. We hope it will be found that the results of our labors are at least satisfactory in regard to this harmony of facts, so that we may call it a system. The conjecture, also, that there is not, north of Spitzbergen, a region of firm ice extending to the Pole, and that there is only a not very broad belt of pack ice, though containing also very large fields of ice, to be penetrated in order to reach an open sea, will, from the above composition of facts, have gained more weight than it had already.[232]

It was, however, not our intention, as the reader himself will have seen, to favor any undertaking for the purpose of reaching the Pole. This should be left to the practical navigator. The thinker must finally stop in his researches, not only where he finds subjective limits, but also where nature places objective bars, beyond which nothing remains but, as our great poet says, "to worship the inexplicable." But what has been attained by our review will not be without use, also, for the practical navigator, directly for whalers, as well as indirectly for the general theory. The latter, or, more correctly expressed, the completion of the general geographical or telluric system of the oceanic currents, was our especial purpose.

The principal results of our researches are, in short, as follows: As egressive currents there are two streams, one from the east and the other from the west, flowing along the circumference of the circumpolar basin, where, in the winter, a shore border of continental ice is formed, which they float in the summer to the aperture. Thus a moving ice belt is created, of about eighty to one hundred and twenty miles in width, in which the whaler finds his game. Scoresby has never reached its northern limit, but Parry has reached and even gone beyond it. The ingressive current (the Gulf Stream) extends from the southwest coast of Greenland to the north coast of Norway. Both the polar streams, the eastern at the southwest coast of Greenland, the western on the east side of Newfoundland, submerge beneath the Gulf Stream, as the antipolar, where the temperatures are 32° to 47° and 32° to 59°. The antipolar currents (the branches of the Gulf Stream) we see submerge at four places, on the west sides of Nova Zembla, of Spitzbergen, of Iceland, and also of South Greenland, where the temperatures are about 38°.8 to 32°. That there is also a current along the central line of the basin to the aperture, is indicated by facts.

IV.

APPENDIX.

PRELIMINARY REPORTS

OF THE

SECOND GERMAN NORTH POLAR EXPEDITION,

AND OF

MINOR EXPEDITIONS IN 1870.

[The following papers appeared in the "Mittheilungen" of the Geographical Institute of Justus Perthes, after the foregoing had been given to the printer. They contain the preliminary reports of the Second German North Polar Expedition, which has just returned home, and of minor expeditions still in the field, the labors of all of which will add materially to the knowledge of the northern extension of the Gulf Stream.

These outline sketches are added here in translation with the view of republishing the scientific results bearing upon the Gulf Stream as soon as they are elaborated and published in Germany.—HYDROGRAPHIC OFFICE.]

A.

THE SECOND GERMAN NORTH POLAR EXPEDITION,

FROM

JUNE 15, 1869, TO SEPTEMBER 11, 1870.

Report of Captain Koldewey.

[The expedition, placed under the direction of Captain Koldewey, who had also conducted the first expedition in 1868, consisted of two ships, the new steamer Germania, of 143 tons and 30-horse power, under the immediate command of Captain Koldewey, and the sailing yacht Hansa, of about the same capacity, and commanded by Captain Hegemann.

The scientific gentlemen accompanying the expedition were Dr. Börgen, astronomer; Dr. Copeland, physicist; Lieutenant Payer, geologist, and Dr. Pansch, naturalist, on board of the Germania; Dr. Laube, physicist, and Dr. Buchholz, naturalist, on the Hansa.—HYDROGRAPHIC OFFICE.]

I. THE CRUISE OF THE STEAMER GERMANIA.

The expedition left Bremerhaven June 15, 1869, in presence of his Majesty the King. The ships were towed into the North Sea by tug boats of the North German Lloyd, and started on their northerly course with a breeze from the S. W. The wind, however, shifted soon to the N. W., and prevailed from that quarter during the following weeks, detaining the vessels so much that the first ice was not seen before the 15th of July, in latitude 74° 49′ N., longitude 10° 50′ W. of Greenwich. The Hansa had been lost sight of, in the meantime, during a thick fog off Jan-Mayen, but was again met in latitude 75° N., and taken in tow by the Germania. The weather, during the succeeding days, was foggy; the ships lay on and off to the southwest, and parted again, on the 20th of July, in a fog and through the misinterpretation of a signal. The Germania met Rosenthal's steamer Bienenkorb, by which letters were sent home; she then penetrated into the ice. Unsuccessful attempts to break through were made, under steam, in various places, and continued to the 29th of July, when the Bienenkorb was seen again; then a northerly course was taken along the edge of the heavy ice, to try it further north. Everywhere, however, the ice was found completely closed. In latitude 74° N., at last, loose drift ice was found, through which the ship could apparently make its way. Steam was got up, it being nearly calm under the ice. For twelve hours, until 10 o'clock of the next morning, (August 1,) no obstacles were encountered; the pieces of ice were sufficiently loose to steer through them without difficulty, and nearly two degrees of longitude were gained, when we again came to firmly-packed ice.

The Pendulum Islands were now in sight, and, beyond the packed ice, the open water, anxiously looked for, could plainly be seen, really existing. As the ice had shown, in the last hours, a tendency to break toward the east, the ship was made fast to it, to wait for a change; this position was evidently the most favorable which could have been reached.

For the following days thick fogs prevailed, but otherwise the weather was good. On the 3d of August the air cleared; we had drifted to the east, but the ice to the west had loosened more. The Germania now steamed on; we soon came to great fields, between which, however, were channels wide enough for the ship to pass; in a few instances force was required. After passing the meridian 17° W., we were beyond the most difficult part, and could proceed with more ease, until, at 5 a. m. of August 5, we came to an anchor in three fathoms water, on the south side of Sabine Island, one of the Pendulum group. During the passage through the ice, as many soundings and temperature observations had been made as the circumstances would permit.

In the succeeding days Sabine Island was surveyed, its geographical position proving in accordance with General Sabine's determination; the magnetic constants were ascertained, and the other necessary labors carried out by the scientific *personnel* of the expedition, all of which were finished by the 10th. A mountain permitted a far view all around; it was, however, not a gratifying one, as the shore ice was seen to be broken only on the south side of the Pendulum group, while to the north, between the main and Shannon Island, it lay completely firm. There was no trace whatever visible of open water along the coast north of latitude 74° 32′. Firm ice, some years of age, extended, without the least break or even a crack, for some miles east of the easternmost islets, the southern coasts of which only were partly free. A passage, however, to the southeast point of Shannon Island, and perhaps farther, appeared p ssible.

We steamed, really without difficulty, to Cape Philipp Broke, and found, also to the east of the island, between the ice bordering the coast to a distance of about four miles and the packed ice, a navigable channel, one to three miles in width; in a few places only there was a bar of thick pieces of ice, through which, however, the ship could readily break. The shore ice was at the edge, in some places, 40 feet high, a warning witness of the immense pressure of the fields.

In latitude 75° 31′ N., longitude 17° 16′ W., our advance was suddenly checked; the field ice connected here firmly with the shore ice, and no water at all could be seen north. The ship was made fast to the shore ice, in order to wait and see whether a change might occur; but in vain. The strong refraction of the light on the following days exhibited but too plainly the fact that there was no open water to the north for a great distance.

Under these circumstances it was unanimously concluded to anchor, if possible, on the south side of Shannon Island, in order to explore it. From its mountains the movement of the ice could be watched, and ascertained whether the fields toward the north would drift away. The shore ice had broken away, during the last days, from Cape Philipp Broke, and the Germania was anchored there in three fathoms water at noon of August 16. The exploration of the island was commenced immediately, and continued until finished. Shannon Island is considerably larger than shown on the charts; the north-eastern point lies in latitude 75° 26′ N., longitude 18° W., and the west coast runs nearly due north. The island makes, on the whole, a sad impression. There is, however, on the plains of the west coast, in places, sufficient vegetation to furnish food for the herds of the musk-ox, which we found here. The first animal of this species met with was shot at Cape Philipp Broke on August 16.

Our hopes for a change in the ice were not realized. The pack ice, on the contrary, came from the east closer to the coast; even the part between Shannon and Pendulum Islands which, in the beginning of August, had been free, now filled in. Our anchorage became more insecure every day; therefore when, on August 26, the scientific labors were completed, and no one could see a possibility for the present of penetrating further north, it was deemed best for the purposes of the expedition to return to Pendulum Island, in order to explore it also, and to prepare a sleigh-expedition for the exploration of one of the fiords. Our only hope for the further progress north in this season rested upon the gales of the autumn, which possibly might tear an opening in the ice.

The ship consequently turned south again, August 27. In the last nights so much young ice, now already about an inch thick, had made between the drift ice that we could push through only with full steam, often having to repeat the assault in the same place. A sailing vessel would have been completely helpless, as there was but little or no wind. Calms are decidedly prevalent on this coast in the summer, as we had occasion to observe in both years. The Germania came to anchor, at 11 p. m. of August 27, on the south side of Little Pendulum Island, in five fathoms water.

The first part of September we were occupied with the survey of the group and scientific explorations, hunting in leisure hours the musk-ox, reindeer, &c. The ice did not part; even some violent gales from the north made no impression on the inert mass. The shore ice between Shannon Island and the main remained unchanged; the ship was confined more and more to closer quarters, and even an attempt to enter Gale Hamke's Bay failed, as this also was already full of heavy ice. During the calms more young ice formed, and though it broke again with each northerly wind, there were all the signs of the approach of winter.

On the 13th of September the Germania lay again inside of the small harbor on the south side of Sabine Island, in which she had anchored August 5. The preparations were now completed for the sleigh-expedition into the interior, on which the party assigned to it started at noon of the following day. On the preceding night again young ice had made in the straits and around the ship, so that we found it rather difficult to work the boat to the old ice, which was to the westward of the ship, distant from it about four miles. On the latter, however, the water pools were already completely frozen, and the travel in the sleigh was therefore pretty quick and easy. During the following days we penetrated into the inner part of a fiord (bight) which had been free of ice in the summer, but was now covered with smooth ice three inches in thickness. A mountain, 4,000 feet high, was ascended, and angles taken from the summit for the chartographical labors of Lieutenant Payer. This summit offered a fine view for great distances over the surrounding mountains and far to the northeast over the sea. In the latter direction, beyond the north point of Shannon Island, the eye could detect nothing but ice. The fields had not yet moved, and probably had never parted from the shore ice. It now proved inevitable, as all had expected, that we would be compelled to winter at Sabine Island, the only practicable and secure winter-harbor on the entire coast between the parallels of latitude 77° and 74° N.

On the return to the ship Lieutenant Payer discovered, on an island, brown-coal beds and found numerous petrifactions. The vegetation on this coal island was, in comparison with that of Shannon Island, rich, especially in andromedæ, (heath plants.) Large herds of the musk-ox and reindeer grazed there. We could kill from the tent as many of these animals as we chose, but unluckily could take only few with us, as the sleigh was already heavily laden.

On the 22d of September we arrived again on board. Those who had remained there had not been idle in the mean time; various preparations for the winter had been made, the ship carried further in, some musk-oxen, reindeer, polar bears, and walrus killed, &c. A violent gale from the N. had blown in the night from the 20th to the 21st, but had not been able to break and drive off the young ice; this had already a thickness of some inches, permitting us to go over it on board.

The preparations for the winter were now entered upon to the fullest extent. By sawing through the ice the ship was brought still further in, until she lay in 10 feet water, but a short distance from the land. A single night was sufficient for her to freeze in firmly and immovable, so that neither anchor nor chains were needed. After that the greatest part of the movables and of the provisions were transferred to the shore, the engine was taken to pieces, the cabin enlarged and fitted, the yards and the running gear taken down, and the deck completely roofed over. On the shore two observatories were built, one for magnetic and the other for astronomical observations; and in the latter the meteorological instruments were suspended and fixed, which from that time were read every hour. Moss was collected and the deck of the ship covered with it some inches high. Lastly, a wall of snow and ice was erected around the ship. The ice had, in the middle of October, formed to the thickness of fifteen inches.

We now could quietly await the winter. Our arrangements were such that we could produce a great heat with comparatively little fuel, and, in fact, the consumption of coal never exceeded, throughout the winter, 70 pounds a day, even in the greatest cold, (—40°;) the heaters of Meidinger of Carlsruhe proved to be most excellent. The proceeds of hunting during the autumn were about 1,500 pounds of fresh meat, furnishing nearly daily throughout the winter fresh reindeer or musk beef for all hands.

Toward the end of October a sleigh expedition, in a southern direction, was undertaken by Lieutenant Payer and Dr. Copeland, resulting in the discovery of a new fiord, a survey of which was made. The expedition returned November 4, in good health, although much fatigued from very great exertions. This was the last of all the greater excursions for 1869.

On November 5, at noon, the sun appeared, for the last time this year, above the horizon; it was not seen again before the beginning of February. Polar bears also, which had thus far been at all times around us, were no more seen; the reindeer and the musk-ox withdrew to the better pastures at the heads of the fiords. Nature had assumed a rigid and lifeless aspect; the polar night of three months was before us. The general disposition of our little company, however, was nevertheless very cheerful; no one feared great hardship or sickness, as we had all the means to conquer successfully the rigidity of winter. There was also no lack of occupation or entertainment; the field work of the past season and the present observations were to be computed, and smooth copies of the records made; drawings had to be made, and even the regular routine service occupied some hours daily. A fine library on board, presented by publishers, was diligently availed of; besides it, a navigation school was instituted, which found much favor with the crew. Time thus passed quickly; Christmas, the middle of the polar night, came before the absence of the daylight had been much felt. The only annoyance were the frequent snow-storms from the north, some as violent as hurricanes, which often prevented for days all moving about in the free air and even under the roof of the deck. The snow, in the form of fine dust, penetrated through all the joints and crevices of the wall and the tent-canvas, so as to cover the deck in places some feet high. The heaviest storm, and of longest duration, blew from the 16th to the 20th of December, with uninterrupted violence, often in hurricane-like gusts, which made the ship, although it was firmly frozen in the ice, tremble from the keel to her tops.

This northern gale broke the ice which already had attained a thickness of some feet, 300 paces south of the ship, and also east of the island, so that now a narrow channel of open water was visible along the southern coast. We were thankful that the small size of the ship had permitted her to be brought so close to the shore; a larger vessel, which must have remained in

16 to 18 feet of water, would surely have broken loose, and must have been lost among the ice so violently agitated by the hurricane. After this gale the weather was quiet for some days; light and warm southerly winds raised the temperature, which had been as low as —17° to —19°, at Christmas to +25°. This, however, was, on account of the arrangements against the cold weather, in the cabins more inconvenient than the severest cold. Christmas-Eve was celebrated with open doors, and there was dancing on the ice in the starlight. A small Christmas-tree, composed of evergreen heath plants, (andromeda,) was lit, the cabin decorated with flags, and on the table the gifts were exhibited which friends at home had laid in for the purpose. Every one received his part, and happiness reigned throughout the ship.

After the holidays the various problems to be solved with the change of the weather were thoroughly considered. Preparations for the sleigh-excursions of the spring were entered upon at once; tents, covers, boots, and other apparel were either made new or altered, according to our own experience of the last fall; sleighs were repaired, cooking utensils made, provisions packed, &c.

On New Year's Eve we bade adieu to the old year which, with the exception of but few mishaps, had in the whole been favorable to us, and entered upon the new with the best hopes.

January brought mostly beautiful and quiet weather, though again a temperature of from —13° to —40°; so that many astronomical and magnetic observations could be made. The aurora borealis appeared in its sublimest glory, and was carefully observed by Drs. Börgen and Copeland, who obtained valuable results.

In the last days of January the twilight at noon grew gradually brighter, and the meteorological instruments could be read for some hours without the aid of a lamp. Everybody looked longingly for the appearance of the sun, now soon to be expected, the long absence of daylight at last beginning to influence the good humor. On the 3d of February, the sky being completely cloudless, we saw with great joy, from the summit of a near mountain 800 feet in height, the sun rising at noon above the horizon in full splendor.

At the same time we had also a view over the ice outside. As far as the eye reached nothing but a connected white mass was visible; no crack or crevice anywhere; all frozen close together. Only along the coast was thin young ice, as since the December gale each successive strong blow had partly torn the freshly formed ice.

With the appearance of the sun business was entered upon more lively; greater excursions were made into the interior of the island, in which, however, the always armed parties had to use great precaution against the polar bears, which now began to stroll about; nevertheless some surprises occurred, happily without serious results, though the attacked were sometimes pressed hard; one of the scientific gentlemen received an ugly wound in the head, and was carried along by the bear more than 200 paces; he recovered, however, in a few weeks. The astronomers began to lay out a base for the measurement of an arc of the meridian. But snow-storms set in again with the greatest fury, and it became so cold that the thermometer fell to its lowest figure this winter, (—40°;) we, however, had not the pleasure of seeing the mercury frozen. The winter, in general, was not a very severe one, and the temperature on the whole pretty even, which may be attributed in part to the water opening with each storm.

In the beginning of March all the preparations were finished for the first great sleigh-excursion north, the objects of which were especially geographical exploration and hypsometrical measurements. We left the ship on March 8 at 9 a. m. in two sleighs, manned by twelve men. The second sleigh, under command of Mr. Sengstake, the first mate, was to provide the principal sleigh during the first week with provisions, to leave a small depot, and then to return on board in order to prepare for the excursion of the astronomers who intended to explore the area over which the triangulation for the measurement of an arc of the meridian was to be laid.

Our voyage in the beginning, as far as the young ice of one year's growth reached, was quick and easy; but as soon as we came to the old ice the road became worse with every step. The storms had torn large holes in the snow, and although the latter was hard and firm, the sleighs moved with such difficulty that all hands were compelled to draw first the one sleigh, and then return for the other. After a fatiguing day's march we had not reached the northeast end of the island; the sleighs had necessarily to be lightened, and provisions were deposited in a covered place; the tents were then put up for the night. The next morning we went on, but with no better success; it was concluded, therefore, to add two men to the greater sleigh, to enlarge its tent, and send the smaller sleigh back at once;

these labors were finished in the afternoon; Mr. Sengstake went back, and we erected our tent about a mile from the northeast end of the island. The temperature had, in the mean time, fallen to —29°, but our covers gave us sufficient protection. Much was yet to be altered in our arrangements; we found that our mode of life had to be simplified much, in order to make better progress; the dead weight of the sleigh could perhaps be lessened sixty to eighty pounds by reducing the utensils and the apparel to the absolutely indispensable. When, therefore, on the next morning the temperature was found to be still so low that the sleigh could be drawn over the snow only with the greatest difficulty, we turned homeward to carry out these various changes. We left the provisions on a mountain, and arrived at the ship in the afternoon of the 11th, a little frost-bitten, but otherwise well.

It was fortunate that we returned. A series of violent gales would have prevented all progress, and compelled us to remain in the tents, which is more weakening than the most fatiguing march. At last the weather appeared to change for the better; the new and more simple arrangements were made, and we started again on the 24th of March. But the temperature had not changed in the great ice desert north of the Pendulum Islands. We again found —29°; nevertheless we made fair progress during the first days, marching from eight to ten miles over the hilly ground, and we would surely have reached a far higher latitude if the permanent snow-storm blowing directly from the north had not proved an unconquerable obstacle. We were compelled, sometimes from two to three days, to lie in the tents, firmly incased and exposed to all hardships. Fortunately our tent was so well arranged that no storm could destroy it, and we were entirely secure in that respect, but the fine dust penetrated everywhere, and everything in the tent was covered by inches of snow. Part of the latter melted from the cooking in the tent and from the warmth of our bodies; our clothing and covers became wet, we shivered constantly, and sickness appeared unavoidable. Our strength grew less, notwithstanding that the sun came out for a few days; greater rations had to be allowed than estimated for, and snow had frequently to be used to quench the thirst. Good luck willed that at Haystack, which we reached on April 3, and which is not an island, as heretofore supposed, but connected with the main, we shot a polar bear, which furnished fuel and some meat.

In latitude 76° 24′ N. we came to a region in which the snow lay remarkably loose, so that we had to wade through it sometimes to our knees; the storm which everywhere else had made the snow hard and firm had here apparently not touched it at all. With all exertion we could make but two miles a day, keeping always the main to our left. Further on we soon learned the cause of this looseness of the snow. The coast of Greenland runs out here into a great bay open to the south, to the east of which a long tongue extends, with an island before it, toward the south; the high land to the north had protected the bay from the storm, and thus the snow under the lee of the coast remained soft and high. To come out again from this bay we had to turn east, when we reached a small bight, which necessarily had to be our northernmost point. The great exertions of the last days, and the low temperature, still below —13°, had caused a rapid consumption of our provisions, while the storms had detained us so much. All that could be done now was to ascend a few heights near the coasts, which would give us a clear view over the land and ice. A terrible snow-storm from the north raged again for the next three days without any interruption; we had to shorten the allowance of provisions; it was necessary, however, to ascend some of the heights, and before doing so we could not think of leaving. On Good Friday, (April 15,) at last, the weather cleared up, and we could start for the heights. After marching twelve miles north we came to a mountain of about 1,500 feet, which we ascended. It is situated in latitude 77° 01′ N., and about longitude 18° 50′ W. of Greenwich, and from it the coast extends due north nearly in a straight line. The view over the sea exhibited, as expected, an uninterrupted field of ice clear to the horizon, over which there was a white ice-sky; the ice was covered with immense humps, far greater than those to which we had been accustomed at Pendulum Island; along the coast, to about a distance of four miles, land ice extended, but that also was of older date, and had evidently been undisturbed for some years. The whole had the appearance of a bulwark built for eternity. As soon as Lieutenant Payer had finished his observations we hurriedly pushed for our tent, as we saw again sure signs of a new gale brewing, and we had just arrived when it broke on us with tremendous fury.

Saturday, April 16, in the afternoon, we were able to start back for the ship. We now intended to travel at night, as we would then have the sun behind us, and could rest in the daytime more comfortably in the tent.

Forced marches were to be made, to reach the ship as quickly as possible, as a second sleigh-expedition, under command of Lieutenant Payer, for the exploration of the fiords, had yet to be undertaken before the thaw set in. Great exertions were made, but the fresh meat afforded good nutriment; the fat of the polar bears, which we secured, gave excellent fuel. The storms, if not too violent, contributed to speed our travel, pushing along the sleigh, to which we had added a sail.

On the 27th of April we returned on board. Now, however, we found how much we had lost in strength, notwithstanding the good food. A dreadful feebleness overcame every one, and nearly all suffered from violent cramps in the legs; but quiet and care on board restored all hands soon.

The sleigh-expedition for the exploration of Ardencaple Inlet could start in the afternoon of May 8. Only two of the men who had accompanied the first expedition, although not unfit for duty, were not strong enough for a distant foot-travel.

Some minor sleigh-excursions, for geodetic operations, had been undertaken, during our absence, by the astronomers, and a part of the basis had been measured. The ship had assumed a different appearance, as the winter covers had been removed, &c. Violent gales, however, had also here retarded progress, and, in addition, the polar bears had, so to speak, laid siege to the ship and its vicinity, so that the utmost precaution had been necessary to avoid fatal accidents. A number of these animals had been shot; to drive them off was found impossible.

These drawbacks were the cause that the geodetic expedition of the astronomers could not leave before the evening of May 14, quite late for the use of sleighs, as the thaw sets in very suddenly, and the snow then loosens and melts with surprising rapidity. This expedition had to contend against very great difficulties. Toward the end of May, even, they had to wade through water, and the glacier rivulets grew, in the beginning of June, so violent that it was very dangerous to cross them. The labors, however, were completed satisfactorily. On the return, the sleigh, with everything that could not be carried by the crew, had to be left in latitude 75° N., in order to reach the ship by forced marches.

Lieutenant Payer returned on the 29th of May. He had met with unexpected difficulties. The dreadful storms which, on the coast, had everywhere hardened the snow, had raged across the fiords with the contrary effect, depositing loose snow to such a depth that all sunk down into it to the waist, and the freight of the sleigh had to be carried piece by piece. In this manner only a distance of a few hundred paces could be traveled a day, with the utmost exertion. A view from the summit of a mountain showed that no better road could be hoped for, and therefore it was decided to return. The excursion, however, was not without valuable results; some hundred petrifactions and fossil plants were brought on board.

The time for sleigh-excursions had now passed, but sufficient rest and recovery from the toils and exertions of the last months could not be thought of, and but a few days could be allotted for it. There were still small excursions required for the completion of the surveys and for botanical and zoölogical purposes; the ship was to be made ready for sea in all her parts, and much was to be done by the few available for it. Though the best testimony must be given to the crew, each of whom was eager in the work, much that was desirable had to be left undone, and it was impossible also to finish completely all the scientific labors which had been initiated.

The thawing process went on speedily; the thickness of the ice, which had, in May, been 6 feet 7 inches, decreased soon some feet. To the east and south of us there was already much open water; the shore-ice broke off gradually on the edges.

July 10, in the evening, the ice within the harbor in which we were still firmly embedded, began to move, and we drifted out of the harbor to the southeast. The saws were put in operation to cut a passage through the ice, which still was 3 feet in thickness. During the next afternoon a channel, sufficiently wide to pass through, had been sawed; we steamed with hurrahs out of our icy prison, but made again for the harbor, now nearly free from ice, where we arrived after a few hours. Some necessary labors were yet to be completed, and a boat expedition to the Esquimaux huts on Clavering Island to be made, before renewing our attempts to penetrate north.

The boat expedition sailed July 14, in the afternoon. The coast was found entirely free of ice to Cape Borlace Warren; in Gale-Hamke's Bay, however, it lay yet in parts firmly, but we were able to row to Cape Mary; the remaining four miles to the village visited by Clavering had to be made on foot, a very tiresome task. We found the village where it was placed on the chart, but the huts were long ago abandoned and decayed; two, probably the same which had been found inhabited by Clavering, were evidently of a more recent date than the others. We examined the huts as thoroughly as the bad, rainy weather would permit, and returned to the boat. The ice in the bay was now breaking and the water, close to the shore, in most places already free; many pieces, two years old, were floating about, a sure sign that the bay had not been entirely free in 1869.

We arrived back on board in the morning of the 18th. The Germania was now ready for sea, and we steamed north in the morning of the 22d, coming-to again at Cape Philipp Broke, to reconnoiter first, from the mountain, the state of the ice to the north. There was again a channel along the shore ice, which appeared to extend pretty far to the north.

On the return to the ship an unfortunate circumstance was unexpectedly discovered, which finally exercised a commanding influence on the discoveries of the summer, and made an early withdrawal from the ice necessary. The tubes of the boiler began to leak, and it became evident that the latter would be unfit for use before long. Without steam, however, as our experience had sufficiently demonstrated, but little could be done on this coast, where calms prevail in the summer, during the short time in which navigation is practicable. The tubes were repaired as completely as possible, and we went on. Ascending through the narrow channel between the shore ice and the packed ice, we reached the parallel of latitude 75° 29′ N., close to the northeast cape of Shannon Island. Here our progress was stopped by the same ice-barrier which we had found in this vicinity the last year. The heavy ice, here in general much higher than at the Pendulum Islands, joined the shore ice, and there were no signs whatever of its breaking soon. From a mountain of the island near the cape, about 500 feet in height, we saw to the north nothing but firm ice, and a strong refraction of the light disclosed the same state also to the east of the high land before us, (latitude 76° N.;) only on the south side of this land a single narrow strip of water was visible. We remained for some days close to the shore ice, but were not able to perceive the slightest motion in it. In the meantime the wind had shifted to the south, and was setting into the bay so much drift ice that we were nearly incased again; and during calms much young ice formed. We, therefore, had to retreat, and it was unanimously concluded to abandon all further attempts to penetrate north, as in order to do so we should have to break through to latitude 77° N. without making any new discoveries, and the boiler might give out entirely, which would, in all probability, have left the ship helplessly embayed. On the 30th of July we steamed south in a thick fog, feeling our way along the shore ice, and now and then breaking through a chain of drift ice.

On the 3d of August we came to anchor south of Cape Broer Ruys, intending to explore that coast, as the ice still lay firmly to the southward and westward, and on the 6th a boat-expedition was made to examine Mackenzie Inlet which, however, was found not to exist; a level valley had evidently been mistaken for an inlet, and what is shown as Bennett Island on the chart connects with the main-shore. There were numerous reindeer in the valley, so little shy that five were killed in a short time. From the summit of a mountain a considerable number of swimming icebergs were seen to the south and the west of Bennett, which apparently were coming from a great fiord. We therefore went next day in the boat in that direction, but after rounding Bennett, and on arriving at Cape Franklin, the shore ice was also there found to lie firmly, barring our progress in the boat. From the summit of a mount we saw the fiord which we had expected to find there, and it seemed entirely free of ice; we concluded on the next morning to draw the boat over the intervening field, but the latter broke during the night and began to move to the east. Lieutenant Payer and Dr. Copeland ascended another mountain about 4,000 feet high, from which they saw that the fiord was far too extensive for an exploration merely in the boat, and that we would have to bring the ship in, there being no impediment after pushing through the drifting ice. We immediately returned to the ship and started steam; the boiler had been mended again, so that forty pounds could be carried. The shore ice was broken through without any difficulty, and we then steamed between the icebergs. The further we penetrated the milder became the temperature, and the warmer grew the water; the scenery was grand, truly Alpine. An unknown country, the real interior of Greenland, more and more beautiful and imposing, opened to our astonished eyes. Numerous glaciers, cascades, and torrents came down from the mountains, which ascended higher aud higher. Further to the north an immense glacier was discovered, surely the source of many icebergs; in steaming to the west and southwest more numerous branches of the fiord opened; no end was to be seen of it. But, unfortunately, the boiler again broke down after twenty-four hours' service, and we were compelled to come-to under a glacier of about 1,000 feet in height. Immediately all necessary labors were set on foot for the exploration; triangulations were carried out, mountains measured, and the entire country surrounding us carefully mapped. Mountains in the interior, in about longitude 32° W., were ascertained to be as high as 14,000 feet. From a glacier nearer to the coast, the summit of which, 7,000 feet in height, which was ascended by Lieutenant Payer, Dr. Copeland and Peter Ellinger, the branching of the fiord was seen to extend everywhere apparently limitless.

In the meanwhile the boiler had again been patched as well as it could be done; it was, however, evident that in a short time we would have to shift entirely without steam power. On this account, and as the season was well advanced, it would have been imprudent to push the ship deeper into the fiord; for, if the boiler failed again, say seventy miles inside of it, the sails would hardly have brought us out in time, as calms prevail there during the summer, and we would have probably been compelled to stay a second winter; the return home was therefore determined on.

We anchored for the last time at Cape Broer Ruys, and saw from its summit that the packed ice, although nearer the coast, was still loose enough to allow a passage. We steamed, though in a thick fog, without difficulty between the field ice until the 16th, when we met thick ice, through which we had to break, but this was the last effort of the boiler; the water poured in streams out of the tubes, and steam had to be blown off quickly; we had, however, reached more open water.

The other part of the home voyage was made under sail. We had, between the ice, one more heavy storm, in which the ship proved again her strength and solidity. There were but few more dangers, and, on the evening of August 24, we reached the open sea, in latitude 72° N., longitude 14° W.

In the next days, during calms, some deep-sea soundings were made to 1,300 fathoms. It was our intention to pass between Iceland and the Faroe Islands on one side, and the Shetland Islands on the other, in order to make there more extensive deep-sea soundings and temperature observations, but the prevalence of violent gales prevented the former and limited the latter; some of these, however, show very interesting results.

Near Helgoland we sent up rockets for a pilot, in vain. We could not understand for what cause other ships, the nationality of which we could not make out, answered by rockets. On the morning of September 11 Langeroge came in sight, but off Wangeroge we could not discover the barrel buoy, the extreme mark for the entrance of the Weser; the light-ship also was not there, nor the Wangeroge spar buoys. We could not find any explanation for all this, and made for a large ship, the masts of which we saw in the outer Jahde. Coming nearer in we found that we had a fleet of war vessels before us, but we could not yet make out the flag. A shot brought us to; officers of our navy came on board, and we learned, to our greatest astonishment and joy, the grand events of the last months.

We obtained tug-boats and pilots for the Weser, and in the evening of the same day we anchored again at Bremerhaven which we had left four hundred and fifty-three days before.

The ship, built by J. C. Tecklenborg, in Bremerhaven, has, during the entire cruise, proved excellent in all respects, and especially well fitted for Arctic navigation. Her small size was favorable for quick and easy maneuvering in the ice, and, consequently, for a speedy progress before the openings made could close again. Her small draught permitted us to keep close under the land, and thus to be better protected against the heavy ice than a larger ship would have been. On the bow she had been strengthened so much that the most violent knocks of the ice, even when at a speed of five or six knots, had no effect at all. Her sharp build prevented all pressure which might have endangered the joints, as she could lift herself readily. The steam power proved, contrary to all expectations, sufficient; with a pressure of forty pounds four and one-half miles per hour could readily be made in quiet water. All the experience of the cruise demonstrates that, at least on the Greenland coast, the employment of larger vessels for expeditions of discovery and exploration would be dangerous. Improvements might, however, be made, for the purpose of still greater safety.

The following is added from the preliminary reports of the scientific members of the expedition:

Doctors Börgen and Copeland have made, throughout the cruise, a connected series of areometric observations, which have given very interesting results, especially in the ice. The surface water in the bays, as also at greater distances from the shore, was found, in the summer of 1870, to be of extraordinarily small density, on account of the great quantity of fresh water which emptied into the sea from glaciers; below the surface, on the contrary, the water proved to be considerably denser, changing, in lesser depths, pretty suddenly, but then increasing the density gradually. With the aid of these observations examinations will be made in regard to the dependency of the density from the temperature, and to the temperature of the sea water at its maximum density.

Astronomical observations were, for the most part, limited to the determination of geographical positions, made at all points where a landing was effected. The position of the winter harbor was fixed by a great number of observed altitudes of stars and of the sun, and, besides, by the observation of the eclipse of the sun of August 7, 1869, of moon culminations, of occultations of stars and of the satellites of Jupiter. The preliminary computation resulted in latitude 74° 32′ 20″ N., longitude $1^h\ 15^m\ 15^s = 18°\ 49'$ W. of Greenwich, very nearly coinciding with the results of the observations of General Sabine at the same place forty-seven years before ours. The final establishment of the longitude requires yet a comparison with corresponding observations at the various observatories.

Throughout the winter stay meteorological observations were made, with two barometers and at least three thermometers. From October to May these were read every hour; before and after that time, every second hour. The mean annual temperature of the winter harbor was found to be 11°.7, the coldest temperature observed being —40°.5. During the winter, especially in April, storms from the north were prevailing of a force unknown in Europe. An anemometer of Robinson, though constructed so as to measure the strength of the strongest winds in Europe, was blown to pieces by one of these storms which showed a speed of more than sixty-seven miles per hour. In the violent puffs of wind the mercury in a marine barometer of Fortin's construction fell several millimeters, (down to 5.)

After the observatories had been built and some difficulties overcome, a series of magnetic observations was made. From December 21, 1869, twenty-four hours were devoted every two weeks for the observation of the oscillations of the magnetic declination, which were referred to the preceding and the subsequent absolute determinations of the declination. In these observations, as also in the meteorological, Doctors Börgen and Copeland were assisted by the commander of the expedition, by officers Sengstake and Tramnitz, and by Peter Ellinger, seaman. An induction inclinatorium was employed for the first time in the Arctic regions; it has proved, as had been expected, the most appropriate instrument for the establishment of this constant. The magnetic intensity was ascertained, in the summer of 1870, by several careful observa tions. The preliminary values for the winter harbor are: declination 45° W.; inclination 79° 50′. Besides these, the magnetic constants were ascertained at many other places by smaller portable instruments.

On the 11th of September the first aurora borealis was seen, and since that time this phenomenon was the subject of various observations which, unfortunately, were much interfered with by the gales of the winter. It generally began with a bright arc which formed in the southeastern quarter of the heavens, in various altitudes above the horizon. From this arc rays and irregular spiral streaks of light extended generally all around, converging near the zenith; the exact point of convergency was well determined in several instances. As was expected, its altitude above the horizon was found to be exactly equal with the magnetic inclination, and its azimuth equal to the declination.

Greater oscillations of the magnetic needle, in conjunction with the aurora borealis, were observed only once; when, for a second time, the oscillations were very great, (amounting to several degrees,) the sky was unfortunately obscured. Frequently, however, the needle remained very quiet when there was a very bright aurora.

In the spectroscope a bright line of greenish-yellow color showed, the position of which, with reference to the natrium line D, was ascertained after repeated failures; it lies between b and D, distant from the former about one-third of the distance between both. More accurate data cannot be given for the present, as Kirchhoff's solar spectrum is not at hand. On the home voyage we had occasion to observe, in the vicinity of the Shetland Islands, an aurora which completely coincided with those observed on Sabine Island, and showed a very sharply defined point of convergency.

One of our problems was a reconnoissance for the measurement of a degree of the meridian, which it is proposed to carry out at a future time. With prominent authorities we believed that we could not solve this better than by a possibly accurate triangulation, by which good information could be obtained in regard to the topography, signals, atmospheric relations, &c. Preparations for this were made throughout the spring, and the triangulation carried out in May, June, and July. The unfavorable state of snow permitted the measurement of only a small arc of forty minutes, and only at sixteen stations of the seventeen selected, for the same cause, could the angles be measured. We have, however, become fully convinced that no serious obstacles will be found in the final measurement, especially as the weather in summer is favorable and the air is always very transparent, and, with a covered sky and during the night, very quiet.

When in the fiords we were able to ascertain, in a short time, a daily forward movement of a glacier amounting to five inches, with the probable error of hardly one inch.

Photographs were obtained in considerable numbers.

Lieutenant Payer conducted the geographical labors: a trigonometrical triangulation with the theodolite along the east coast of Greenland and over the islands off, and the fiords within it, on a basis measured on Sabine Island; the triangle points were marked by pyramids of stone. Hypsometric measurements were done with the theodolite, and with mercury and aneroid barometers; and the summits of many mountains were ascended for the purpose. The chart will also show in detail great mountain ranges in the interior, with their glaciers. Close to the coast were only the beginnings of glaciers, mostly created by local agencies, (drift-winds, &c.;) the interior, on the contrary, contains a grand glacier development. The largest observed had a longitudinal axis of sixteen to twenty-four nautical miles; of the largest of all the glaciers of northeastern Greenland we saw only the precipitated mass. The greatest glacier walked over by members of the expedition measured twelve miles in its longitudinal axis.

The snow line, so called, is as little perceptible in Greenland as on the Alps; there is only a demarkation line of glaciers. In conformity with Alpine experience the Greenland glaciers also show an enormous decrease.

The highest mountain measured was found to be 14,000 feet high, and lies at a distance from the east coast of a third of the width of Greenland; it is probable, however, that higher mountains exist.

Lieutenant Payer advances the opinion that Greenland probably is a complex of islands, which, separated by fiords and immense sounds, are of very different size.

The geological formation of East Greenland is preponderingly crystalline; there are, especially, syenits resembling gneiss, frequently with lodes of basalt. On the coast brown-coal formations were met with not unfrequently. The geological collection is considerable, especially in petrifactions and fossil plants.

The labors of Dr. Pansch were those of the surgeon and naturalist; happily he had not much to do in the former capacity. We all have returned well; the members of the expedition have all proved strong enough for the exertions which were required of them. All the arrangements and the supplies (as provisions, clothing, heating, and airing apparatus) were found to answer admirably. There was no sickness at all except two wounded, and the winter stay has not affected the health of any one. It must be stated, however, in this connection that hunting has furnished about 5,000 pounds of fresh meat.

The scientific results in botany, zoölogy, and ethnology during the stay on the coast, considering the many obstacles and difficulties, must be called satisfactory. As the expedition remained there the four seasons, the entire vegetable and animal life can be reviewed. The vegetation was found to be very diversified according to the locality; in one place waste an poor; in the other luxuriant and manifold. We saw meadows, and we found butterflies; mosquitoes were at times so numerous as to be very annoying. Very many herds of reindeer were seen, some numbering fifty head; it is especially remarkable, and was not expected, that we met the musk-ox, not only singly, but sometimes sixteen head together. Among other animals the lemmings and ermine must be named. Walrus were also found in schools, but whales were not seen on the east coast; fish, however, were found on the coast as well as in the inland waters and salt-water lakes. Birds were fewer than we expected; grouse, gulls, ducks, divers, crows, and various singing birds hatch there. The lower order of animals is rich and interesting. We did not meet with Esquimaux, and saw no fresh traces of them; but the marks of old settlements were found nearly at each point visited. The huts of the Esquimaux village, described by Clavering, were much decayed; they had probably been abandoned soon after his time, that is, forty years ago. A dozen well-preserved skulls from Esquimaux graves were brought home. The utensils found at various places—as for instance slides of very large sleighs, dog skulls, kajak oars—indicate that the people who have lived here, compared with other Esquimaux, were by no means of the lowest order of culture.

2.—THE CRUISE AND LOSS OF THE SAILING YACHT HANSA.

[FROM A PRELIMINARY REPORT BY THE BREMEN COMMITTEE.]

After the Hansa had, for the last time, lost sight of the Germania, on July 20, 1869, she was steered north, in order to penetrate between latitudes 74° and 75° through the ice for Greenland. She succeeded in approaching the coast on the 24th of August to within twenty-four miles, and a boat went about eight miles nearer, but all attempts to reach the coast were in vain, and on the 19th of September, in latitude 73° 06′ N., and longitude 19° 18′ W., the ship was completely frozen in. In the ship's journal the following is now recorded:

In this situation we remained for several weeks. On the morning of the 19th of October, during a thick snow-drift, and with a strong wind from the northwest, which soon grew into a storm, the ice in our immediate vicinity began to push; it tore away a part of the field by which we were incased and thus far protected, and placed us in great danger.

At times there were lulls in the roaring of the grinding ice; we then only could see how the ice rolled about and large pieces of our field broke off and drifted away. Shortly after noon of the same day the masses pushed upon us, which already had attained a considerable height, had broken the young ice, of about four feet in thickness, on the starboard side of the vessel, and drove it hard against her. The ship lifted herself somewhat forward, but as she could not do so sufficiently, on account of the high ice blocks, she had to suffer the full power of the pressure. Shortly before 1 o'clock the seams of the deck amid ships sprung, but the hull appeared to be still tight. A short pause succeeded this strong pressure which then began anew with increased force. The Hansa lifted herself first slowly, but then rapidly until she had risen 14 feet and was entirely on the ice, when the pressure relaxed and the ice before her gave way so that in an hour the ship leaning over to starboard could slide into the now open water; she remained, however, over a tongue of ice in an inclined position.

The pumps were now sounded, showed 11 inches, and immediately after 12 inches of water in the hold; they were worked until 7 o'clock p. m., when a little rest was taken to eat; 10 minutes after that there were 30 inches in the hold. The storm and snow drift ceased toward 9 o'clock, the sky cleared, and it grew severely cold, the thermometer showing —13°. The water from the pumps accumulated between the provisions which on the previous day had been placed on the quarter deck; part of it run off through the cabin hatch back into the hold, but a considerable part froze on the deck, blocking the scuppers so that it became necessary to break through the bulwark; this, however, was of small avail as the ice grew thicker.

On the 20th, at 4 p. m., after having worked the pumps throughout the night, with difficulty on account of the ice, and not being able to discover the leak, we gave the ship up. Water was already pouring into the cabin from below. The ship had apparently broken her back, and was leaking through all her seams.

Everything necessary for our support on the ice was saved, but not all the provisions. Such things as collections, &c., could not be thought of. We attempted also to hold the ship fast by means of hawsers and ice anchors. On the 22d the masts were cut, and the greater part of the cordage put away. On the evening of the same day we had, however, to cut the hawsers and ice anchors in order to prevent the breaking of the ice on which our goods were stowed.

On the 23d of October, at 2 a. m., the ship sunk; the largest boat, which had been standing free on the deck, remained on the surface; the two other boats had before been placed in safety on the ice. The approximate position in which the ship sunk is latitude 70° 50′ N., longitude 21° 00′ W., hardly four miles from Liverpool coast, the precipices and mountains of which, resembling remarkably the Lime Alps near Munich, were plainly in sight; Holloway Bay and Glasgow Island were also distinguishable, but no passage could be discovered through the labyrinth of ice.

The sinking of the ship concludes the first part of our Arctic voyage, (from June 15 to October 19, 1869, one hundred and twenty-seven days.) On the 20th of October the ship's company, consisting of fourteen men, stood, with the few saved goods, helpless in a wide ice-desert. But they did not despair; they knew that the ice would drift south and carry them, in about three-quarters of a year, to regions where a rescue was possible. And indeed, on the 13th of June, 1870, all hands were saved, two hundred and thirty-seven days after the loss of the ship. This ice-voyage along the coast of East Greenland is an incident which will long be remembered.

On the 20th of October the wrecked people rested their weary limbs, for the first time, in the floating hut built of coal, in which they were to live for eighty-seven days by the light of a petroleum lamp. The hut was standing on a great ice field, seven miles in circumference, and had been erected at the end of September to place the provisions in safety; it was comparatively small; 20 feet long, 14 feet broad, and of a height of 4½ feet at the walls, and 6 feet in the middle of the roof which was constructed of spars and planks. Provisions and clothing were saved in sufficient quantity, as also the cooking stove; the masts and other parts of the ship saved furnished fuel; but nearly all the scientific instruments, and the collection of skins, drawings, and photographs were lost. Of what use would these things have been in the small hut, which had only a passage of 2½ feet for standing and walking? How could they have been taken afterward into the boats, where each square inch, each pound of weight counted?

The life in the house, as regards regularity, watches, and division of labor was similar to that on board the ship, and the sleeping places were like the bunks of the ship. Close to the house was a high pole, with the black, white and red flag which, a true symbol of home, withstood all the hardships, and was finally handed back again to the committee. The cold was, in the average, not more severe than —17°.5; a few times the thermometer fell to —24°; once, for a short time, to —26°.5; the heavy fur coats were only used as covers for the night. The coast was discernible nearly always in clear weather. Polar bears and white foxes visited the hermits now and then. Who can know whence they came and what wanderings they had accomplished, the former swimming, the latter jumping from field to field? They might have come from the shore, but men would surely have been lost had they attempted to go there in the same manner; perhaps it might have been possible with the utmost exertions, but the provisions and the boats must have been left behind.

The drift to the south continued uninterruptedly. At the end of December the parallel of latitude 68° was reached. Nearly 3° south of the place of the wreck, Christmas was celebrated. In regard to that, we read in one of the diaries as follows:

"On Christmas-day we had rain. While in the afternoon we took a walk, the mates raised the Christmas tree, fitting into a broom-staff corn bushes to resemble pine tree limbs. For candles I had saved a wax taper.

Paper chains and home-made honey cakes were the ornaments of the tree; the crew had worked for the captain a knapsack and a revolver case. We opened the two tin boxes presented to us for the occasion by Professor Hochstetter, and by the Geological Institute, and divided the gifts by lottery. In enjoying a bottle of port we perused the old newspapers in which the gifts had been wrapped. In this manner the holy day passed; I forbear to write down the thoughts which come to my mind; they were the same with all. If this Christmas is the last which we live, it is still a happy one; but should we return, the next will be the happier. May God will it!"

New Year brought no friendly welcome; the greatest dangers occurred in January, 1870. On the 2d of January the ice voyagers were in latitude 67° 47′ N., longitude 34° 01′ W., close under the coast, in a bay which they called "Bay of Horrors." Of that day one of the diaries records: "A sudden strong rumbling of our field drove all hands from their couches; we had no idea what this could be, as outside a heavy storm was blowing; had it been clear we would have been in still greater anxiety. Although the door hole was stopped up by snow—in fact, the entire hut was covered more than a foot by the ice—all rushed out, but in the darkness no one could see anything more distant than ten paces, and nothing could be heard except the fury of the storm. Laying down flat, the ear to the ice, we could hear a noise like the singing of the ice when it is pressed hard, or the grinding of it when passing over rocks; there was no doubt that we were in the greatest danger. We laid down again on our couches, dressed, waiting anxiously for daylight. The weather grew worse. About 10 o'clock in the forenoon, when the wind and the snow drift had abated in some degree, some of us walked through the deep snow toward the part of the ice near which the Hansa had gone down; but two hundred paces from the house we saw, to our horror, great masses of ice piled over each other, the limit of our field of ice. The latter was broken up as far as we could see—dark objects which could be recognized through the thick snow-drift as the remains of the field; it was broken evidently into many parts, of which that on which the hut stood appeared to be the largest, but might also be broken up at any moment. We filled our knapsacks, so as to hold out as long as possible in case of a sudden flight which, however, would have left little hope, as, in such a snow-drift, one sinks at each pace into it up to the armpits, and perhaps into the very jaws of destruction."

Similar scenes occurred on the same day repeatedly, but the worst night was that from January 11th to 12th, when there was the greatest danger of losing the boats. The company divided into two parties, each standing by one of the boats; the largest boat was given up. Ice-crusts formed in this dreadful weather over the face, and had to be removed by the knife if one wanted to eat; the snow penetrated through all the clothing, the limbs of some of the men froze, and the diaries could not be kept for some time on account of the frozen hands. "Only by a miracle we were saved," says the commander in his diary.

On the 14th of January the field was broken up so far that the house had to be abandoned; for five days the men had to camp during the night in the boats which were provided with covers. On the 19th of January a new hut was finished, built of the remains of the old one, snow being used for mortar; but it was only 14 feet long by 8 feet in width, and only six persons could sleep in it, while the others had to seek rest in the small cooking house and in the boats. Thus they lived for one hundred and eight days—to the 7th of May. The once large field was then but a piece of drift ice; when the people left it, its circumference was hardly two hundred paces; its small size was, however, an advantage in the region of swimming icebergs, the pieces winding their way frequently between these colossi as if steered by an invisible hand.

On the 7th of May these intrepid men left the piece of ice which had borne them for two hundred days. They were now in latitude 61° 12′ N., longitude 42° W. The south coast of Greenland, with its strong tides which must have become dangerous to that little piece of ice, and Cape Farewell, with its gales, could not now be far off; the provisions began to fail, and open water appeared toward the coast. The three boats, which had always been kept ready, were brought, within four hours, into navigable water. Captain Hegemann took the Hope, Mate Hildebrandt the Bismarck, and Mate Bade the King William. With three hurrahs the cruise was commenced, but after two days, when the boats had approached the coast to within three miles, they met an impenetrable ice barrier. It was concluded to draw them over the ice, which brought again camping on the ice. This lasted twenty-five days, from the 11th of May to the 4th of June, during which period, of herculean exertions, only half-rations could be served; the boats could be moved only five hundred paces a day; the meals had to be warmed on alcohol lamps; snow-blindness broke out, and the shade glasses of the instruments had to be used instead of the snow-goggles, which had been lost. At last, June 4th, Idluitik, a small rocky island, in latitude 61° N., was reached, and Sunday was celebrated there on the ice. From the 6th to the 13th the three boats sailed down the coast, along the precipices which commenced to show signs of vegetation; there were again obstacles and violent gales, which were weathered. On the 13th a broad bay opened, red houses were seen, and then people, looking in astonishment on the strange voyage; a kajak hurried past, hugging the coast. "There is our German flag" sounded from the land over the water. Rescue was at hand at last! The first fellow-beings who shook the hands of the wrecked were German countrymen. The missionaries of Fredericksthal, Messrs. Starik and Gerike, received them kindly, and nursed them until the 16th. The tale of the unheard-of ice voyage spread rapidly among the Esquimaux, and all came to congratulate the adventurers.

On the 16th of June, the anniversary of the expedition, the rescued learned that they could soon start home, as the Royal Danish brig Constance, Captain Bang, would sail within a short time from Julianshaab, which, however, first had to be reached. On the 16th the boats sailed to Nennortalik; on the 17th to Lichtenau. From the last place a messenger was sent to Julianshaab, but alas! he found the ship gone; luckily she had to return on account of the thickness of the ice, and Captain Bang, a native of Schleswig, invited his countrymen most kindly on board. "On the 22d of June we left the boats of the Hansa, which had served us so faithfully. On the 1st of September we landed at Copenhagen, and were astonished to learn from the pilot the tidings of the great war and the sublime victories." Thus the diary of Captain Hegemann closes.

The company on board the Hansa, who all reached home in good health, were Captain F. A. Hegemann; Dr. phil G. Laube, Professor in the University and Polytechnical School of Vienna; R. W. Buchholz, M. D., professor at the University of Greifswalde; first officer, R. Hildebrandt; second officer, W. Bade; carpenter, W. Bowe; and the seamen Wübkes, Heyne, Kewell, Gätgen, Schmidt, Tilly, Büttner, and Gierke.

Captain Hegemann praises the crew highly. Insubordination was unknown; all orders were cheerfully executed, even under the most difficult circumstances; there hardly occurred a single harsh word.

The adventures of the intrepid voyagers, and the results of this remarkable expedition, are so manifold that the latter cannot be called meager. It has failed to be an expedition of discovery, but considerable geographical data were obtained, and much of scientific value, especially in meteorology and for the knowledge of currents. The expedition is a piece of German sea life, from which the greatest credit accrues to the German seamen.

B.

MINOR EXPEDITIONS IN 1870.

Besides the German national expedition, an account of which has been sketched on the preceding pages, there were in the Arctic region, during the summer of 1870, a Swedish scientific expedition, and some private parties, the latter mainly for hunting or pleasure, but with the intention, also, of collecting geographical and physical data. The following are abstracts from the preliminary accounts of these, published in "Justus Perthes Geographische Mittheilungen" of September, November, and December, 1870:

I. THE SWEDISH EXPEDITION.

The Swedish Geographical Society, intending to send to the polar regions, in 1871, an expedition of greater dimensions, with the intention of wintering in West-Greenland, directed Professor A. E. Nordenskiöld, who had been intrusted with previous expeditions, to go there in order to prepare for it. Accompanied by Dr. Berggren, of Lund; Dr. phil. Nordström, of Stockholm; and Student Öberg, of Upsala, he left Copenhagen May 16th, and arrived at Godhavn July 2nd. The only notice thus far received from the party is dated from Christianshaab, (latitude 69° N.,) July 29th, 1870; it is mainly an account of an attempt to push, as far as possible, over the inland ice, which reaches to the innermost shores of the Auleitsivik Fiord, previously attempted with little success by Dalager in 1759, and again by Whymper in 1867. They were able, with the greatest difficulty, to penetrate, as they estimated, 30 to 40 miles, to an elevation of above 2,000 feet above the level of the sea, where they could see before them the same unbroken field of ice for about the same distance without termination. The temperature rose in the day to 79°, but at night the water froze.

The expedition was expected to return at the end of November.

II. THE EXPLORATIONS OF VON HEUGLIN AND COUNT ZEIL IN AND NEAR EAST SPITZBERGEN.

The cruise of Theodore von Heuglin, the ornithologist and explorer in Northern and Central Africa, and Count Waldburg-Zeil-Trauchburg, though undertaken for pleasure, has added very important data to the knowledge of the north. Mr. von Heuglin, before starting, had communicated with Dr. Petermann, and has forwarded to him accounts of his observations as often as an opportunity offered.

They left Hamburg in a steam packet June 4th, well provided with good surveying and meteorological instruments, and began immediately to make regular observations of the temperature of sea and air, (four times daily,) and to collect specimens of the water for analysis. In Tromsö they hired a small schooner, had her strengthened, and sailed, July 3rd, for the Thousand Islands.

On the 10th of July they passed Bear Island, but were prevented by the fog from seeing it. On the 12th, about fifteen miles south of the parallel of the South Cape of Spitzbergen, but considerably to the east of it, they came up with the drift-ice, which compelled them to turn to the west and make for the South Cape. The temperature of the air near the ice was 37°.6, and that of the water 30°.9.

On the 15th the South Cape was passed to the west, and on the 17th the vessel came to anchor in a small bay north of Horn Sound, where she remained, for want of wind, until the 27th. It proved quite difficult to weather the South Cape and to land on the eastern coast. On the 9th the vessel came-to under Cape Lee, from where Walter Thymen's Fiord was visited in a boat, and thoroughly surveyed, as it was found to be laid down grossly incorrect on the charts. There was also a fair chance to cut in by angles a cape of Gillis Land, or an island adjacent to it, in latitude 78° 52′ N., longitude 25° E. of Greenwich, northeast, east, and southeast of which many snow-covered mountains were clearly seen, from which the size of Gillis Land may be estimated equal to that of Spitzbergen. The sea east of Spitzbergen proved full of large flakes of drift-ice. Mr. Heuglin believes, however, that a steamer might readily have pushed through it.

Next, Helis Sound was visited, and many points on its shores astronomically determined. A current was observed there of six miles per hour. From there the vessel turned back again for the Thousand Islands, but the cold weather now setting in caused ice to form rapidly, and a succession of gales prevented further surveying, except some in Deevie Bay. After a short visit to Bell Sound the vessel was steered back for the coast of Norway, arriving at Hammerfest on the 26th of September. Violent gales were experienced during 26 of the last 29 days.

The observations on the return passage showed, around Bear Island, the same considerable decrease of the temperature of the sea, as well as of the air, which had been noticed on the passage north, and by previous expeditions. The temperature of the sea on September 17th, off Bell Sound, was 34°.7; the next day, more to the south, 42°.6; and 50 miles S. by W. from the South Cape 39° to 41°; it then rose on the 21st to 43°.2, and on the 22d to 43°.9 and 44°.8. Eight miles west of Bear Island the temperature of the sea was observed to be but 35°.6, (that of the air being 36°.3,) it then rose again, toward the North Cape, rapidly to 39°.4, 41°.0, 41°.9 to 46°.0.

A change in the color of the sea (indicative respectively of the Gulf Stream and the Polar Stream) was not observed on either passage. The water appeared, under a favorable sky, always dark blue, with the exception only of shoal places, for instance in Walter Thymen's Fiord and some parts of Stor Fiord, where the water had a decided green color. The Eastern Arctic Sea was found to be dark blue, although it is surely polar water. The principal stream is, however, said to set along the east coast of Stans-Foreland to the north. A discoloration of the water sometimes takes place by the melting of the drift ice, when innumerable sea-nettle congregate there, resembling a submarine snow drift. The great blocks of ice coming from the northeast, and frequently of a depth of fifteen to twenty fathoms below the surface of the sea, are mostly of a gay beryl-green color.

Tides were only found close in shore. The rise and fall on the east coast, in general, was three feet; in Stor Fiord, however, it was four feet; causing the violent current in Helis Sound, and in the Walter Thymen's Strait.

That there are currents in different directions at the different depths, especially in Stor Fiord and in Walter Thymen's Strait, is shown by the greater icebergs swimming frequently with great velocity in a direction directly opposite to that of the smaller fields and flakes, even against the wind and the tide.

Great attention was devoted to the drift-wood. The most was encountered on the shores of Walter Thymen's Fiord, and on the east coast of Stans-Foreland, the greater part larch-fir, frequently logs of fifty feet and more in length, mostly with the roots, less frequently with branches, but always without bark. There were some close to the high-water mark apparently but lately deposited; the older, decayed, lay on terraces which had been lifted evidently at different epochs, as they were sharply defined against each other. There were also some in the alluvium, between rubble and débris, some feet beneath the present surface, as could be seen in the deep ravines cut by the ice rivulets. Besides the logs of the larch-fir there were pieces of bark of the same tree, also pine and birch bark, the latter in thick rolls, and a wood which Mr. Heuglin thought to be juniperus. The bark, as well as the logs, showed frequently bore-holes by caterpillars of apparently two species. On the Thousand Islands the drift-wood is rare; more of it was found in the Stor Fiord, and even some in Ginevra Bay.

All the parts visited were examined geologically, and a rich collection was brought home of the various minerals, petrifactions, &c. The magnet permeating the prevailing hyperite affects everywhere the compass needle, and was evidently the cause of the great declination reported by Koldewey at Cape Torrell. Considerable coal was found on the southeast coast of Stans-Foreland.

Mr. Heuglin believes that Gillis Land may be reached more readily from the south; best perhaps in a boat, or in a small but strong steamer, provided at the bow with a circular ice saw.

The expenses of the two gentlemen who have done so well, were, after deducting their share in the profits of the chase, only about 1,200 Prussian thalers, ($800.)

III. THE CRUISE OF SHIPMASTER E. ULVE.

The Norwegian, E. Ulve, while chasing in the waters of Nova Zembla from April to August, 1870, made regular observations of the temperature of water and air, and of the barometer, and forwarded the record by Mr. von Heuglin to Dr. Petermann.

He found in Matotschkin-Shar (Matthew Straits) a temperature of 41°, and a still higher in the Kara Sea. Mr. von Heuglin attributes the cause of this high temperature there, as also of the complete and quick melting of the vast masses of drift ice of which the Kara Sea is replete in spring, and also the cause of the shoals and shallow places extending far to the north, to the fact that that sea is in many respects but the extended mouth of a river.

It is remarkable that the same glass balls and fishing buoys, of which Admiral Irminger speaks in the memoir appended to Dr. Petermann's paper, (page 93 of this volume,) as found on the Iceland and East Greenland coasts, were also found by Ulve and by Johannesen on the northwest coast of Nova Zembla. One of the buoys had a Norwegian inscription; in all probability they have drifted there from the Lofotes.

IV. THE CRUISE OF CAPTAIN JOHANNESEN IN 1870.

Captain Johannesen sailed, in the summer of 1870, entirely around Nova Zembla. He found the north coast of it very erroneously placed on the charts, especially the North Cape, which he makes to be in 77° 08′ N., and 71° E. of Greenwich. His observations of the temperature, together with those of Captain Ulve, will prove the more valuable, as they connect with and check each other.

V. THE CRUISES OF CAPTAIN CARLSEN.

Captain Carlsen made to Mr. von Heuglin the following statements in regard to his last and his previous cruises:

There was between Cape Torrell and Thumb Point generally much loose drift ice; but north of the parallel of 81° N., which was passed between the meridians 20° and 21° E., no greater masses of ice were seen.

Walrus and Storö Islands are much closer in shore than shown on the charts.

Captain Carlsen does not deny the existence of Dove Bay, as has been stated erroneously in the narrative of the Swedish expedition, (German edition, p. 479.) On the contrary, he landed in Dove Bay, near three greater islands, close to the Northeast Land, on which he found the remains of a Russian settlement. East of these three islands, and close to them, there is a bight, between two mountains.

Northeast of Storö, between latitude 80° 30′ and 79° 40′ N., there was much ice, in large fields.

The east coast of the Northeast Land is a connected glacier, but on the east coast of Stans-Foreland there are but three glaciers between the mountains, which resemble in shape and height those on the west coast.

Hope Island, which is placed on the charts pretty correctly, is very narrow, and has no harbor. There are seven high and steep mountains on it. Von Heuglin could distinguish only five.

Half-Moon Island must be placed more to the west and nearer to the coast, where there is a bight toward the north, in which a river empties. The strait between the island and the main is one mile in width and averages twenty fathoms in depth.

The direction of the west coast of Gillis Land is, according to Carlsen, W. N. W. and E. S. E. The coast is steep, and before it, lies a smaller foreland with very green slopes. He did not see glaciers there. When passing close to the land it was surrounded by fields of drift-ice, between which there were everywhere navigable channels.

VI. LAMONT'S CRUISE IN 1870.

Lamont started again, on the 16th of April, to hunt east of Spitzbergen and to make geographical observations. He has not been heard from yet.

VII. THE EXPEDITION OF THE GRAND DUKE ALEXEI, OF RUSSIA, IN THE IMPERIAL CORVETTE WARJÄG, 1870.

This expedition appears to have obtained most important data in regard to the northern extent of the Gulf Stream, as will be seen from the following note addressed to Dr. Petermann by Von Middendorff, a member of the Russian Imperial Academy, who accompanied the Grand Duke:

"On my return home I found on my table your memoir on the Gulf Stream. You have treated the subject most clearly, and carried the Gulf Stream eastward beyond the North Cape to the Taimyr region, and even into the New Siberian Polynja.

West of the North Cape your array of figures is irresistible, but east of it your conclusions are very bold. With the exception of Bessel's 41°, you had no direct proofs. I rejoice that I can, not only, confirm your suppositions, but even go beyond them. You have been daring; nature is more so.

I have been able to-day to demonstrate, before the Russian Imperial Academy, that the corvette Warjäg has proved the extension of the Gulf Stream to the west coast of Nova Zembla, and that we found it on the meridian of Kanin Noss, (43½° E.,) still of a width equal to two degrees of latitude, and of a temperature of 54°, cooling down, at depths of thirty and fifty fathoms, only from four to six degrees. I will state here, preliminarily, that on your Chart No. 1

1. The July isotherm of 10° R. (54°.5 F.) must be transferred from the White Sea to latitude 70° N.

2. A branch of the Gulf Stream is probably cut in two by Kanin Noss which is washed by water of 52°.3 in temperature, and runs along the east coast of the White Sea.

3. A cold water band, on the contrary, of a temperature of 43° to 41° runs along the west coast of the White Sea.

4. The water has, on the meridian of Koljugew, still a temperature of 50°, which decreases, up to Kostin Shar, to 45°.5 and 42°.

5. From Tromsö to Iceland your curves prove excellently correct.

We have not seen a single piece of drift ice, although we penetrated, in the end of July, to latitude 71° 12′ N.

Our course was as follows: From Archangel to the Solovetsk Islands; thence along the west coast of the White Sea to Kanin Noss; from thence to the Seven Islands, the Kola Bay, Waranger Fiord, to the boundary line of Norway, Wadsö, Wardö, Hammerfest, Tromsö, Iceland, and then past the north coast of Scotland home.

VIII. THE EXAMINATIONS OF TH. JARSHINSKI IN THE WHITE SEA AND ON THE MURMANIAN COAST, 1869.

The zoölogical researches of Th. Jarshinski, along the Murmanian coast of the Polar Sea, prove the affinity of the fauna there with that of the Atlantic Ocean, and point to a current along that coast, coming from the Atlantic Ocean.

The "Iswestija," (vol. vi, No. 6, of August 10, 1870, pp. 213 to 217,) has the following remarks in regard to this:

"The temperature of the water in the southern part of the White Sea and in the strait between the Ter coast and the Green coast was, in fact, only 37°.4 and 40°.1, that of the air being 44°.6 and 53°.6; in July only the temperature of the water rose to 57°.2, and that of the air to 73°.4. The same was observed east of the Holy Cape, (Swätoi Noss,) in the direction of the Kanin Peninsula; with a temperature of the air at 57°.2 and 62°.6, the water remained at 40°.1, even at a depth of eighty fathoms; and only after three days, when the temperature of the air had obtained 66°.2, that of the water on the surface rose, with a quiet sea, to 42°.8.

"Entirely different are the temperature relations west of Swätoi Noss; while, on the coast and in the bays, the temperature of the water appeared independent of that of the air, it remained nearly always stationary at some distance from the coast; and in the vicinity of Kola Bay the temperature of the water was observed for three months to be in the mean 44°.6, (that of the air being in the mean 46°.4,) which is some degrees higher than further east. Sometimes the temperature of the water (42°.8) was even higher than that of the air (41°.)

"These relations have been observed so frequently that there is, at present, no doubt of the extension of a branch of the Gulf Stream along the Murmanian coast. It is further proved that this branch, which is very effective at the Fishermen's Peninsula, (Rybatschji Polnostrow,) and in the Kola Bay, weakens toward the east, but is still perceptible east of Swätoi Noss, and that therefore this branch of the Gulf Stream flows in these latitudes northeast, that is, toward Nova Zembla.

IX. SSIDOROFF'S CRUISE TO THE MOUTH OF THE PETSCHORA.

The same number of the "Iswestija" contains an account of this cruise. Mr. Ssidoroff found, at the mouth of the Petschora, Norwegian glass balls. On the north coast of Nova Zembla he observed a decided easterly current, as also in the Kara Straits; while the current in Jugor Schar appeared to depend upon the winds.

V.

REFERENCES AND NOTES.

A

REFERENCES AND NOTES TO DR. PETERMANN'S PAPER.

Notes.

[1] "Geographische Mittheilungen," 1865, pp. 150, *et seq.*, and table 5: Chart of the Arctic and Antarctic Regions from the Poles to the 20th degree of latitude north and south, showing the status of their geography in 1865, the oceanic currents, &c. The notes on the Gulf Stream, pp. 154 to 158. 1.

[The citation is from a memoir by A. Petermann: "The North Pole and the South Pole, and the Importance of their Exploration," accompanied by the chart named above. The passages of it relating to the Gulf Stream are incorporated into the various parts of the present paper.—HYDROGRAPHIC OFFICE.]

[2] Polar chart, illustrating A. Petermann's paper on the opening into the Polar Sea between Spitzbergen and Nova Zembla. (Further correspondence and proceedings connected with the Arctic Expedition. Presented to both Houses of Parliament by command of her Majesty. London, 1852: pp. 142, *et seq.*) 2.

Professor J. G. Kohl, in his "History of the Gulf Stream," 1868, refers to Von Baer, Kane, and Dove as authorities for the extension of the Gulf Stream to Nova Zembla and Siberia. But the citation, as printed in his books, cannot be found in Von Baer's memoir, and the latter speaks only in one place of the Gulf Stream near Spitzbergen, not near Nova Zembla. (Bulletin scientifique de l'Académie Impériale de St. Pétersbourg, 1838: iii, p. 158.)

What Kane says in his discussion of December 14, 1852, (Bulletin of the American Geographical and Statistical Society, January 1, 1853, No. 2, p. 89,) is from my letter to the British Admiralty of January 23, 1852. (Compare British Blue Book: "Further Correspondence and Proceedings connected with the Arctic Expedition," pp. 142, *et seq.* Also, Athenæum, January 17, 1852, and Petermann, "The Search for Sir John Franklin." London, Longman, 1852, pp. 5, *et seq.*)

The chart, published by Kane with his memoir, in 1853, is a copy of my "Polar Chart, illustrating Dr. P. C. Sutherland's Account of Captain Penny's Expedition, 1850 and 1851, and showing the Chief Physical Features of the Arctic Regions."

In translating the passage of Kane's discussion: "The Gulf Stream, after dividing the Labrador current, has been traced by Professor Dove to the upper regions of Nova Zembla," Kohl says that Professor Dove *and the Russian Academician von Baer* have done so, but, in fact, neither of them has. Professor Dove only *infers* the extent of the Gulf Stream to Nova Zembla *from the general direction of the isothermal curves.* (Transactions of the Berlin Academy: 1848, p. 209.)

In Humbold's "Kosmos" (1845, vol. i, p. 327) the Gulf Stream is shown extending only to Ireland, the Hebrides, and Norway.

[3] Besides at other places, pp. 155 to 158. 3.

Notes.
4.

[4] Geographische Mittheilungen, 1867, pp. 184, *et seq.;* and 1869, p. 35.

[The following extracts from the two monographs contain the passages relating to the Gulf Stream.—HYDROGRAPHIC OFFICE.]

I. FROM THE "NORTHERNMOST LAND OF THE GLOBE," (MITTHEILUNGEN, 1867, PP. 184, ET SEQ.)

3. *Currents, and their influence on climate, vegetation, animal life, and man.*

The geography and hydrography of the Arctic Ocean are still waiting elaboration. We have attempted geographical compilations for the Antarctic, the material for which is comparatively little and easy to master; but for the Arctic there has accumulated so much that a thorough elaboration of but single branches would require years. It is not to be wondered at, therefore, that there is so much vagueness in regard to a part of that ocean, as much frequented and explored as Baffin's Bay, and that even its currents, although sharply defined, are not yet completely recorded.

It has been generally assumed that a broad and deep stream of cold water traverses the entire length of the bay from north to south, and that a counter-current, also of cold water, entering around the southern cape of Greenland, proceeds along the western coast of the latter as far as Disco Island, where it ceases. This erroneous conception we have still entertained in table 5 of the "Geographische Mittheilungen" for 1865, as also Herm. Berghaus, in the latest edition of the "Chart of the World." Lately, however, A. Mühry has shown that this counter-current is not a cold, but on the contrary a warm stream; in fact, an arm of the Gulf Stream.

[Compare A. Mühry on the system of currents in the circumpolar basin of the northern hemisphere, "Geographische Mittheilungen," 1867, p. 66. A translation of this very interesting memoir is annexed, and will be found on page 135, *et seq.*, of this volume.—HYDROGRAPHIC OFFICE.]

This fact could have been ascertained long since from the log-books of the numerous expeditions which have gone to the bay. A single one of them, that of the first Grinnell expedition under De Haven and Kane, would have been sufficient to show it. The latter, an extraordinarily full one, (compare Kane, the United States Grinnell Expedition in Search of Sir John Franklin: New York, 1854, pp. 509, *et seq.*,) is even accompanied by a current chart, drawn by Charles A. Schott, which, although representing its contents by no means exhaustingly, shows clearly enough the principal features of the currents.

On this chart we see two currents running through the entire length of Baffin's Bay; the one, a colder, from Lancaster Sound along the west coast toward the south; the other, a warmer, entering in latitude 50° N., and proceeding along the east coast up to Melville Bay. Exactly the course of this eastern warmer current is the route of the ships going to Lancaster Sound or Pond's Bay. It is a standing rule with them to sail on a great arc extending far to the north. They follow the western coast of Greenland to about Wilcox Point, (74½° north latitude,) thence they hold across Melville Bay for Cape York; from thence they keep on or near the 76th degree of latitude to the middle of Baffin's Bay, when they head southwesterly either for Lancaster Sound, (in 74° N.,) or still more southerly for Pond's Bay, (in 72½° N.) This circuitous route, carrying the ship some degrees higher north than the port, is adopted because on it an open sea, Notes. 4. (Con'd.)

or, at the worst, navigable breaks through the drift ice can be counted on with certainty.

This stream, however, which opens the route, does not cease in Melville Bay, as Schott and Berghaus assume on their charts, and is not cold water; but, on the contrary, it first begins there to show distinctly, in grand effects, its character of a branch of the Gulf Stream. Meeting in its course toward the north the first obstruction—the coasts of Hayes' Peninsula, which project far to the west—its entire volume is deflected westwardly; all the ice coming from the north, the west, (from Jones' Sound,) and the southwest, is pushed aside with irresistible force, and thus an always open and navigable basin is created, which has been named by whalers the "north water." From here a part of this warm stream returns south, carried off by the cold currents which discharge through the northern and western sounds, (Smith, Jones, and Lancaster;) but the main pursues its way further north, along the Greenland coast, and can be traced very distinctly to the northern limits of Smith Sound. Already the first navigator of this sound, Inglefield, records a strong current which he followed from Cape York to Cape Hatherton, and which he observed to have, at the entrance of the sound, a force of not less than seventy-two miles in twenty-four hours; and this current is established with certainty by the experience of his successors, Kane and Hayes. The logs of their expeditions are not published, and no direct observations of the currents there appear on record; but both these explorers narrate facts which give better evidence in regard to the currents of this region than isolated direct observations could convey. Like Inglefield, they prove that, within this warm stream, vessels may proceed at all times, with ease and speed, from Melville Bay to and into Smith Sound, and that the entire eastern half of these waters was always found open and navigable. On the opposite western coast, on the contrary, where the current sets from north to south, an accumulation of drift ice is met with in nearly every instance.

Most distinctly is the influence of the current to be seen in Smith Sound itself, where the water was found open and navigable up to the northernmost point, (Pelham or Cairn Point.) To the north of this point vast masses of ice are encountered, which, at least during the three years of Kane's and Hayes' stay in Rensselaer Bay and Port Foulke, had so accumulated, and were so thick and firm, that it was possible to travel over them in sleighs in all directions. The barrier of ice in Smith Sound, under the influence of the two currents from north and south meeting here, has a northwest and southeast direction, from Cairn Point to Cape Isabella.

Not only in the summer is this spur of the Gulf Stream open and navigable, but also throughout the entire winter, even the most severe, and when immense masses of ice pour through the various seas and from the glaciers of the neighborhood. This is even the case in the comparatively narrow Smith Sound. Hayes records that, throughout the long winter night at Port Foulke, at the lowest temperatures, he could hear distinctly from the ship the beating of the waves; the temperature fell below the freezing point of mercury, (—41°,) but the sea in the sound remained open. (Compare Hayes, The Open Polar Sea, p. 361.) On this open sea the Esquimaux depend altogether; it admits the walrus, without which they could not exist.

The results of this warm stream are grand. Foremost among them is the possibility of human beings living and existing on Hayes' Peninsula, where there are

Notes.

4. (Con'd.) permanent habitations, the nearest to the Pole. No human beings are living on all Parry's Archipelago; in fact, none north of Lancaster Sound. (Compare "Geographische Mittheilungen," 1859, p. 1.) The northernmost Danish settlement in West Greenland is Upernavik, and even Esquimaux villages are not found higher than in 73° north latitude, where the glaciers of Melville Bay begin, which, covering a coast of nearly 280 nautical miles in length, are of more grandeur than the Humboldt glacier, discovered by Kane, of but 40 miles in extent. The existence of men appears to be impossible on this long stretch of the coast. The Esquimaux of Southern Greenland do not extend their hunting excursions into this region, and have no knowledge of it; while European ships and exploring expeditions cannot penetrate into it on account of the ice, of which the sea, along the glacier coast, is always full. But north of it, where the warm stream, after flowing through a deep sea, bounds directly against the coast, which has turned in a westerly direction, we again meet men—the Esquimaux of Hayes' Peninsula, the "Arctic Highlanders" of Ross, a powerful race, able, poorly armed, to conquer the colossal polar bear, and to overcome the not less strong and dangerous walrus, in a four hours' fight on weak ice. Kane found permanent settlements of these Esquimaux as high as Etah on Smith Sound; that is, as far as the warm stream predominates to a certainty.

There is the greatest possible contrast in the effects resulting from the two streams meeting here, as they presented themselves to Kane in Rensselaer Bay and to Hayes in Port Foulke. At the former place the northern cold stream is impressing its influence upon its surroundings; in the latter, the southern warm stream. The scientific observations of Hayes, those for temperature inclusive, are, unfortunately, not yet published, and the climatic differences can, therefore, not be shown by figures; but the descriptions of the natural phenomena express them distinctly. The basin named after Kane never opened during the two years of his stay there, although it is twice as broad as Smith Sound; while at Port Foulke no firm ice at all formed, and even small bights were hardly bridged over between the innermost points. The Esquimaux hunt sometimes on the coast of Kane's Basin, but they never stay there permanently. They call the sea between Smith Sound, Whale Sound, and the Cary Islands, "Utlak Soak," that is, "the great sea basin, the water caldron, or the boiling basin," to distinguish it from Kane's Basin, which is always filled with ice. (Kane, II, p. 213.)

The center of this water basin, warmed by the Gulf Stream, is probably Whale Sound, as the warm stream flowing into it appears to be least affected and cooled down by the cold streams, which discharge all around. Here the most developed vegetation is found, and always a fabulous number of sea animals; and here is the last resort of the whole Esquimaux tribe, when everywhere else hunting fails or nature becomes too severe. Hayes found, in 1861, a third of the tribe here assembled, and none north of it. Already Bylot and Baffin were astonished by the immense number of whales which they met here, and from which they called the bay Whale Sound. Inglefield found it entirely free of ice, containing vast quantities of sea weed, and swarming with sea animals. When landing he was struck by the comparatively luxuriant vegetation. (Inglefield, Summer Search, pp. 58, *et seq.*) Kane also observed, on Northumberland Island, a luxuriant vegetation and vast numbers of birds. (Kane, I, pp. 333 and 347.) Hayes lastly describes the green meadows of that island as a paradise—the most luxuriant oasis north of the Danish settlements of South Greenland;

(Hayes' Arctic Boat Journey, p. 92;) and he confirms this in the narrative of his second voyage; (Hayes, The Open Sea, p. 433;) adding that the sea is filled with immense herds of whales and walrus and the air by "myriads of butterflies." Musk buffaloes also are said to exist still south of Whale Sound. (Hayes, The Open Sea, p. 390.) Their bones are found on all the coasts of Hayes' Peninsula. Notes. 4. (Con'd.)

The distance between Kane's and Hayes' winter quarters is almost 36 nautical miles, but the difference of the temperature, in the fauna, &c., is so great that Kane's expedition must have perished without the resources of Etah, the settlement of the Esquimaux near Port Foulke. The proceeds of the chase at Rensselaer Bay were very small, almost nothing; no walrus or seal was found there, and reindeer very rarely; but for the walrus meat obtained in Smith Sound no member of the expedition would have seen home again. At Port Foulke, on the contrary, great herds of reindeer were met all the winter, and more than two hundred head were killed by members of Hayes' expedition, furnishing the most excellent fresh meat; and, in addition, hares, foxes, seal, eider-geese, and other birds. The principal food of the Esquimaux, during the winter, is the walrus, of which there is, at all times, an abundance in the open sea at Port Foulke. (Compare Hayes, The Open Sea, p. 345.)

The open sea in Smith Sound, even in the winter, was for Kane a phenomenon, for which he could not account in the face of the terrible cold and the ice, against which he had to contend at Rensselaer Harbor. (Kane, ii, p. 32.) He did not think of the currents and their influence, and he does not appear to have made observations of the temperature on his excursions to the southward. Hayes very frequently alludes to the mild climate of Port Foulke in contrast with the low temperatures found elsewhere. In November, 1860, the thermometer rose to +32°, and rain was falling, which Hayes had in Rensselaer Bay only observed in the height of summer, in July and August. On the 16th of March, 1861, Hayes, while on a northern excursion, observed at Cairn's Point —68½°, when at Port Foulke the thermometer showed —27°; thus on the same day the temperature at the latter place was higher by 41½°. (Hayes, pp. 193, 194, and 280.)

II. FROM "THE NEWLY DISCOVERED POLAR LAND AND THE EXPEDITIONS TO THE ARCTIC SEA NORTH OF BEHRING'S STRAITS FROM 1648 TO 1867." (GEOGRAPHISCHE MITTHEILUNGEN, 1869, p. 35.)

The prevailing current, setting in the spring and summer through Behring's Straits in a northerly direction, proceeds principally northeast, but near the coast, between Cape Krusenstern and Point Hope, it is deflected partially northwest, one branch flowing between the Siberian coast and the newly discovered land, and another northward toward Herald Island, thus washing the new polar land on its southern and eastern coasts. The latter branch corresponds pretty accurately with the belt inclosed there by the 30-fathom curve, and is well established by the wreck of the Gratitude which, in the beginning of July, 1865, was abandoned thirty miles west of Point Hope in latitude 68½°, and longitude 168° W. of Greenwich, and was seen again in the following month (August) near Herald Island. (See Pacific Commercial Advertiser, January 18, 1868.)

Captain Raynor expressly mentions having seen this northern stream at Herald Island free of ice. (Pacific Commercial Advertiser, November 9, 1867.)

Notes.

4. (Con'd.) In the fall and winter the current sets in the opposite direction, southward through Behring's Straits, for which fact we also have obtained new data and explanations by whalers, who have wintered at various points.

The statements of Von Wrangell in regard to the currents on the Siberian coast fully agree with this. He says that in the summer they flow to the westward, in the fall to the eastward. (Wrangell, ii, p. 254.)

But a current coming from Cape Barrow sets also in the summer to the south, until it encounters, in latitude 69½°, the warm stream from the southward. To the influence of this current it may be ascribed that north of Point Hope an extensive submarine terrace has formed reaching from that cape to latitude 72½°, between the meridians of 169° and 176° west of Greenwich, and culminating in the Herald Bank, on which there is only a depth of seven fathoms. The warm stream, meeting here this polar current, melts and destroys the ice of the latter, and causes the débris of earth, stones, and rocks, which were carried along with the ice, to be deposited; thus, in all probability, the sea has shoaled here, as at Newfoundland, Spitzbergen, Bear Island, and other regions, where two such streams run against each other.

The influence of the currents is shown most strikingly by the nature of the coasts north of Behring's Straits, that of the American which is washed by the warm stream, and the so widely different one of the Asiatic coast which is more exposed to the cold currents. Never, perhaps, has the contrast been so clearly expressed in a few words as by Edward Mohr, of Bremen, who in 1851 came there with a German mercantile expedition. He says, (E. Mohr, "Reise- und Jagdbilder aus der Südsee, Californien und Südost-Africa:" Bremen, C. Schünemann, 1868, p. 21.) "The difference in the character of the vegetation between the shores of the Kotzebue Sound and the Asiatic coast in the same latitude is striking indeed. While in Asia all vegetation, with the exception of moss, some lichens, and a few small plants which creep along the ground, appears dead, and a dreary polar desert impresses the mind with melancholy and sadness; trees grow on Chamisso Island to the height of twenty feet, and the ground is covered with small bushes which bear red and blue edible berries so plentifully that we could carry buckets full of them on board the Rena."

5, 6. [5 and 6] Proceedings of the Royal Geographical Society, xiii, p. 103:

[The following is the paper read by Mr. Findlay before the society.—Hydrographic Office.]

On the Gulf Stream. By A. G. Findlay.

In the early part of 1853 I presented to the Society, in this room, some remarks on the current systems of the ocean—at that time, as it still is—a comparatively neglected subject. In that paper I advocated the views that each great ocean has a circulatory system within itself, and that there was also a constant intercommunication and intercharge of the whole surface water of the entire oceans. Of this vast circulatory system the Gulf Stream is the best known, as it is the most remarkable of these currents. At that period it was fully believed that the Gulf Stream flowed in one mighty and majestic current of warm water from the surface to its bed, at great depths; and thus there was but little difficulty in believing that its tropically-heated waters could reach the shores of Europe with only a partial loss of the warmth they had acquired. But the first actual experiments, announced soon afterward, dispelled at once all preconceived notions as to its vast magnitude. **Notes. 5, 6.** (Con'd.)

The progress of deep-sea sounding, and obtaining the temperature at enormous depths, as well as determining the nature of the ocean bed, although great, has not kept pace with the requirements of science.

The facts that have since been brought to light, have placed the subject in so much obscurity that it may be really said that we know very much less of the entire system, than was safely argued upon when only the surface-waters were considered. And I think that it would be impossible to generalize any system of ocean-physics which shall satisfactorily account for all the observed phenomena, further than that it is almost certain that there is some sort of circulation and interchange taking place in the lowest strata, as can be sufficiently traced in the surface waters of the ocean.

Now, as much vague surmise and loose assertion has of late been made respecting the possible effects of the Gulf Stream and its influence on the climate of this and adjacent countries, during the late period of unusually high mean temperature, I thought that it might be well to draw the attention of the Society to first principles, and to show what is actually and accurately known of this great current, as derived from later researches. I will, therefore, by the aid of the diagram, point out some of what may, as Mr. Bates has said, be termed "popular errors."

The waters of the North Atlantic circulate, as I have said before, around a central area—the Sargasso Sea; and the western branch of this circuit—that portion which issues from among the West India Islands, after recurring from the intertropical to the extratropical regions—is well known as the Gulf Stream or the Florida Stream. Now, as this mighty current has been traced and measured, both in volume and velocity, along the coasts of the United States as far as Nantucket, we can, from the known amount of each quantity at its entrance into the strait, easily measure its possible effects on distant regions.

The Gulf Stream, at its commencement, is confined between the coast of Florida and those of Cuba and the Bahama Banks, and no other water can reach it during this part of the course. The first section—that at its westernmost limit—was examined, in 1858, between the Dry Tortugas and the entrance to Havana, a distance of 98 miles, which showed that the water gradually deepened from the north side to the maximum depth of 770 fathoms, within five miles of the Cuban shore. The next section will be more suitable for my demonstration.

In 1866 it became necessary to lay an electric cable between the Florida Keys and the Havana, and the United States Coast Survey, under Mr. Hilgard, undertook the examination of the bottom. The line of soundings was carried from Sand Key to the Moro Castle of Havana, in a diagonal line across the main strength of the stream, where it first enters the channel which gives its name, a distance of 82¼ miles. On the diagram this section is represented in its actual relative dimensions of breadth and depth; but, as these are not very visible, an exaggerated section of five vertical to one horizontal is given. To this, and to the next, particular attention is drawn, as they contain the clew to the real character of the Gulf Stream.

Starting from the northern side, the bottom falls away in terraces, nowhere abrupt, to a depth of 504 fathoms at a distance of 29½ miles, and to 687 fathoms at 34 miles, nearly half over. The maximum depth of 845 fathoms is found

Notes.

5, 6. (Con'd.) at $45\frac{1}{2}$ miles from the north side; from this to the Cuban shore the bottom is hilly and precipitous, and at about $20\frac{3}{4}$ miles from the Moro the summit of a submarine mountain ridge is reached, which rises about 2,400 feet above the bed of the strait, that is, from within 380 to 320 fathoms of the surface. This mountain ridge has been traced for more than 12 miles parallel with the axis of the strait, and falling precipitously toward the south, deep water continuing close up to the south shore.

From the northern side the bottom is rocky, with coral, to the depth of 300 fathoms; at depths beyond this it is of that peculiar gray mud, or granular mud, sometimes with red patches, the ordinary type of the organic life of the ocean-bed.

The temperature of the water, varying according to the season from 80° or 84° on the surface, sinks to 60° on the summit of the ridge above mentioned, and is only 45° at the bottom, 13° above the freezing point of fresh water.

In the northern half of this section, above the terraces south of the Florida Reefs, the water lies almost motionless, and it is only over the deep cañons of the southern half of the Gulf that the Gulf Stream flows to the eastward.

It is thus only 40 miles broad in its greatest strength. Its depth cannot exceed the summit of the submarine ridge, and it was found, on hauling in the sounding-line, that the upper moving stratum is scarcely more than *one-third* of the maximum depth. So that the actual sectional area of the Gulf Stream, at its highest temperature and greatest velocity, is not more than 5 to 8 square miles.

Such a well-determined fact shows how entirely fallacious were those speculations formed prior to its establishment. It will be no great sacrifice of preconceived opinion to curtail the Gulf Stream of those widely extended and majestic features with which it was formerly endowed.

The data thus acquired as to its initial course is exactly borne out by further explorations beyond this.

Passing by the next section, between the Sombrero light-house and the Salt Key Bank, about 120 miles further to the eastward, where it is 45 miles wide, (examined in April, 1859, by Commander Craven, U. S. N.,) which showed that its maximum depth is only 600 fathoms, and the greatest depth still being on its southern side, and also the next, between the Carysfort light-house and the Great Bahama Bank, (examined by Commander Craven, in May, 1859,) 63 miles wide, maximum depth about 500 fathoms, we come to the most important, because it is the crucial test of the magnitude and character of the Gulf Stream. Each of these sections is on the diagram before you, and they must speak for themselves.

The narrowest part of the Gulf Stream is, also, by very much, the shallowest part of its course—a fact almost incredible, but that it rests on a solid basis. It was obtained by Commander Craven, in 1855. The distance between Cape Florida and the Bemini Isles is 45 miles, and the maximum depth is only from 300 to 370 fathoms. The temperature of the water at the bed was only 49°, so that here again the warm water does not extend more than one-third or one-half the entire depth, demonstrating the cubical amount of warm water passing over this line to be nearly the same as that shown in the first section, from which this is distant about 250 miles.

Nothing is said here about the cold polar currents in a reverse direction, which have been traced in this its strongest and warmest portion; but a very slight amount of reflection will raise a doubt as to whether such a bulk of water could reach our shores, and transport over so wide an area the influence of the tropical heat of the Gulf of Mexico. Notes. 5, 6. (Con'd.)

A slight glance at its further progress will, I think, convert this doubt into a certainty with every one. It is confined between the Little Bahama Bank and the Florida coast, and from this point to its entrance into the Gulf is about 330 miles.

Hitherto its course has been one undivided stream, lying over a very cold substratum, probably flowing in a reverse direction, and with cold counter-currents appearing near its margin. To the northward it pursues its course, as is well known, generally parallel to the inequalities of the United States coast. But it here appears only as one of a series of parallel bands, the warmest of four belts, having one within it and two (or more) to the east and southeast of it, which warm bands are separated by as many belts of colder water flowing in an opposite direction; and within or inshore is the very cold Arctic current, also flowing southward. The warm belt of the true Gulf Stream is so pressed upon the coast that the exactly defined separation, between its dark blue and tepid waters and the lighter and much colder Arctic Stream, has been termed the "Cold Wall," the division being so nearly perpendicular and well marked to great depths; and this characteristic is preserved as far as, and perhaps beyond, New York Harbor entrance. The outer edge is very vaguely defined, and in its northern portion it imperceptibly blends with the ordinary temperature of the ocean in the same latitudes. Beyond this it turns much more to the eastward, and having arrived at the meridian of the Nantucket Bank, about longitude 68° or 69°, its limits become still less defined, and when it reaches the meridian of 50°, or that of the Newfoundland Banks, its southern margin cannot be detected.

The inner or western edge is very sharply defined throughout its course along the coast of the United States. Why it is so pressed upon the cold Arctic current, with which it does not mix, has never, to my knowledge, been well accounted for.

I might here draw attention to the speculations of Mr. Leighton Jordan, which will very satisfactorily explain it, if his premises be accepted.

He argues that the *vis inertiæ* of the ocean will account for this as far as most other currents; and this is deserving of much attention. In few words, this pressure of the stream upon the coast is owing to the diurnal rotation of the earth, which drives the land upon the ocean waters, the latter being less subject to the axial motion of the earth. For our purpose this very definite feature of its left-hand margin, being very much the warmest and strongest, will bear out more fully the view I am now advocating, as it is that portion more subject to further disturbance, as shown presently.

The length of its course after leaving the Gulf of Florida to the tail of the Newfoundland Banks is about 3,500 miles, and its breadth has increased from about 70 miles off Charleston, 120 miles off Cape Hatteras, at Nantucket to perhaps 300 miles; and its mean annual velocity 65.5 miles per day in the strait of Florida, 56 miles off Charleston, 36 to 46.5 off Nantucket, and 28 miles south of the Newfoundland Banks. So that I have calculated that it would take from twenty to twenty-five days in the main strength of the current to reach Nantucket, or fifty days to arrive off the Newfoundland Banks. Its surface temperature has cooled down from 80° or 84° to 58° in winter, and from 75° to 62° in

Notes.

5, 6. (Con'd.) summer; and, I think, it is evidently a physical impossibility that the volume of warm water which passes through the narrows of Cape Florida could ever make such an impression without some other addition to its strength. The whole bulk of water above 70° in the Florida Gulf would not make a film one hundred feet thick at Nantucket, or fifty feet at Newfoundland. I think it could be demonstrated that the existence of some of the outer warm bands above alluded to, is owing to a drift which curves to the northward outside of the Bahamas. But the observations recorded in the space north of the Bahamas show no evidence of such a drift, which it is difficult to believe does not exist. Having reached the point south of Newfoundland a new phase is arrived at. It here encounters the Arctic current coming down the coast of Labrador throughout the year, and during the spring and summer months transporting the deeply-floating icebergs far into its northern edge, and this northern or left-hand edge has been before shown to be its strongest and most well-marked portion. The struggle between the Arctic and Tropical currents is here so strongly marked that the interlacing of the warm and cold waters, as shown by the thermometer, has been compared to the clasped fingers of the hands; and the veins of each of these distinctly marked ocean waters are so well defined that a few miles, or even yards, is sufficient to carry a ship out or into a tropical influence.

One feature of this down-bearing current is very distinctly marked, and deserves especial attention. On the eastern side of the Grand Bank it is so powerful that, according to the surface isotherms, it penetrates from 150 to 200 miles southward of its general limit, and therefore entirely intersects the surface waters of the easterly stream for that breadth, which, as before stated, is the most important part of its course.

I contend, therefore, that by the time the Gulf Stream has reached this limit its original character is so thinned out and expanded, and its specific character is so destroyed from this cause, and from the neutralizing effects of this Labrador current, that it can be no longer recognized beyond this cold-water gulf, which cuts off, as it were, its further progress, and which, it is manifest, it can neither bridge over nor pass under. The well known northeasterly drift which reaches the shores of Northern Europe, which is *warmer* at 300 miles northeast of the Newfoundland Banks than the Gulf Stream south of them, must be produced by other causes, and has a distinct origin; it is therefore time that it had a distinct designation.

But the evidences of the existence of the Gulf Stream pass beyond this. The gulf-weed it has drifted, the cocoa-nuts and tropical produce which are thrown upon the coasts of Iceland and Norway, the same evidences of its transporting power which are at times found on the south coast of Iceland, and more abundantly in the space south of Cape Farewell, and the drifted mahogany-log which made the Danish Governor's dining table, on the west coast of Greenland, were carried by other powers than that of the Gulf Stream.

It would take, from the data I have reckoned, 150 days to carry any object from the Banks of Newfoundland to our coasts, or 200 days from the West Indies, and this fact, also, combined with what has been said before about the actual bulk of the Gulf Stream, will demonstrate that it is impossible such effects can be attributed to it, because, in addition, it is continuous with that stream which flows southward down the coast of Portugal, the eastern branch of the circulation of the North Atlantic surface waters.

How, then, can the phenomenon of our warm climate be accounted for? The reason is most simple and obvious. The great belt of anti-trade or passage winds which surround the globe northward of the tropics, passing to the northeastward, or from some point to the southward of west, pass over the entire area of the North Atlantic, and drift the whole surface of that ocean toward the shores of Northern Europe, and into the Arctic basin, infusing into high latitudes the temperature and moisture of much lower parallels; and which alone would be sufficient to account for all changes of climate by their variations, without any reference whatever to the Gulf Stream. **Notes. 5, 6.** (Con'd.)

A few words as to the ocean-bed and its inhabitants. The facts cited by Lieutenant Chimmo, combined with those of other observers in most parts of the ocean, demonstrate, as I believe, one important fact, that the whole of the ocean waters are in course of interchange, and that, like the atmosphere, there is a perpetual movement from the surface to the bottom.

If otherwise, and the lower beds are quiescent, how do those minute creatures, almost deprived of motion, exist? They would soon exhaust all their requirements from the waters within their reach, if fresh supplies were not brought them by this circulatory system.

The same organisms are found all over the areas experimented on, whether under the Arctic Circle, or under the heated Tropics, and the ascertained temperatures are nearly the same in all cases, proving that there is a similar water climate throughout.

Another evidence of this circulation is the universality of the composition and characteristics of ocean water. If it were not so, each region would possess a different fauna, having a different description of medium to exist in. It is the same from the surface to the bottom. This was demonstrated by the star-fish brought up *alive* between Greenland and Iceland from the depth of 1,260 fathoms, (1¼ mile.) If these animals had been brought through water of different constituent character, they would have died during the hour it took to haul them in.

Although what has been thus briefly stated may be antagonistic to the generally received opinion, I hold that it cannot be altogether contradicted, and instead of offering any further explanation of known phenomena, I recommend the subject to the zeal of future observers.

Our present knowledge is almost a blank, and the matter deserves every consideration.

[In the same sitting of the Royal Geographical Society a paper also was read by Lieutenant Chimmo, of the British navy, relating to soundings and temperatures in the Gulf Stream, which, with the discussion of both papers by members of the Society, is added.—HYDROGRAPHIC OFFICE.]

Soundings and temperatures in the Gulf Stream. By Commander W. Chimmo, R. N.

Toward the latter part of the year 1868, after H. M. S. Gannet had been upward of three years on the North American and West India stations, she was ordered, during her homeward voyage, to define the northern limits of the Gulf Stream, and to take deep soundings and temperatures within those limits.

Sailing from Halifax, in Nova Scotia, on the 1st of July, the ship passed from water whose surface temperature was 51° to that of 61°, in less than an

Notes.

5, 6. (Con'd.) hour; shortly afterward to 64°, showing that the Gulf Stream water had been reached since leaving that place.

Latitude 43° 20′ *N., longitude* 60° *W.*—To the south of Sable Island, 30 miles, a sounding was obtained of 2,600 fathoms, or 15,600 feet, nearly three miles; with a weight of 232 pounds, and the ingenious machine invented by Brooke, the rod brought up, after four hours' patient hauling, *Foraminifera* in their various forms, chiefly *Globigerinæ;* forms and clusters of three, four, and five chambers. The interior of those fully developed was coated with an apparently fine crystallized, many-colored, quartzose sand; of these forms some were circular, flat, and plate-shaped, having a smooth interior rim, (the *Polycystina;*) the outer margin serrated, and the center coated with the same granular particles; others hemispherical, some single, globular; others fragments as thin and transparent as water. Intermixed with these were particles of transparent many-colored crystals, with *Coccospheres* in all stages of growth and size.

The towing net collected seven species of *Crustacea*, one *Cornucopia*, and a *Janthina fragilis;* the dye from which latter, when placed in a wine-glass of clear water, colored the whole a rich mauve. A very small portion of this apparently impalpable adhesive mud, diluted, and placed under the microscope, showed a field of the most perfectly formed organisms.

The ship next sailed to the western edge of the Grand Banks of Newfoundland, where a sounding of 1,500 fathoms brought up what appeared, under a common glass, minute particles of transparent quartzose sand, with globular forms of calcareous formation; also some *Algæ* with parasitical attachments, probably of lime, but all formed by animal life out of carbonate of lime from ocean waters. The temperature of this mud, or "oaze," as it will be called, was 56°; but at a depth of 1,000 fathoms the thermometer showed 40°.3, and at 500 fathoms only 39°.5, so that the mud probably changed its temperature in passing through a stratum of warmer water, as the sea surface was 60°. This showed an under-stratum of very cold water, there being a difference of 20° between the surface and 500 fathoms, and possibly so at a very much less depth.

Having run north of the limit of the Gulf Stream, again stood to the southward, and soon came into warmer water, at a temperature of 60°; from a cold, damp, penetrating fog, into a mild and summer-like atmosphere; 1,500 fathoms was again found, and the cup brought up the usual grey impalpable mud, (oaze.) The towing net collected a beautiful float of the Nautilus, having 13 chambers, and a fragmentary valve of a delicate fluted Pecten. The temperatures were precisely the same as in the former sounding, except that the surface was 65°, and at 100 fathoms the thermometer showed 50°; a difference of 15° in only 100 fathoms, another proof of the Gulf Stream being merely superficial.

At day-dawn this morning, to the great surprise of every one, we saw an old Labrador friend, a huge iceberg, having a warm bath in a temperature of 62°, double that of its own. Although it was still 150 feet high, and nearly 400 immersed, it was quickly and perceptibly undermining, decomposing, splitting with loud reports, and floating away in large portions with the easterly current.

It curiously happened that this immense iceberg stood in the very spot, 30 miles south of the edge of the Grand Bank, where not only the deepest waters of the Atlantic were supposed to be, but where we intended to get a sounding to ascertain if this were the fact; the result showed it was not so.

Sail was furled, steam got up, and the Gannet ranged up as near as was

Notes. 5, 6. (Con'd.)

prudent under the lee of our chilly friend; and in the midst of a thunder-storm, with Brooke's rod and weights, obtained at a depth of 1,450 fathoms the same "oaze," disproving the idea of the deepest water being here. This depth appears to be not only the usual one, but also the slope of the banks, as well as the general character of their formation.

By the temperatures here obtained, the same stratum of cold arctic water was passing under the warmer waters of the Gulf Stream. The rod brought up a small portion of feldspar with glittering particles of mica, evidently deposited there by icebergs from Davis' Strait, and that very recently.

We now sailed east for the spot where Lieutenant Sainthill, in latitude 42° 37′ N., and longitude 41° 45′ W., obtained, in 1832, 100 fathoms on sharp rocky bottom, bringing up on the arming of the lead "fine bluish ashes;" and he was under the impression that he was over a submarine volcano in a state of eruption. At 2 p. m. on the 12th of July we reached this position, and with a heavy weight 4,300 fathoms of line ran out, and no bottom!

It was somewhat remarkable that about this place, within a radius of some few miles, many indications of shoal water had been from time to time seen and reported, one having as little as 35 fathoms on it. To one of these, called the "Milne Bank," with only 80 fathoms on it, we were now steering. It had been found by H. M. S. Nile, in 1864, on her homeward-bound voyage; and, under most favorable circumstances, soundings of 80, 90, and 100 fathoms, "fine sand and oaze" brought up.

Also, about this vicinity, the currents are found very strong, and a little farther east very variable in direction; sometimes running with a velocity of two, three, and even four miles an hour to the eastward, and in some places forming a complete "race." If neither banks nor shoal-water exist here, it is not easy to account for this additional effort of the Gulf Stream; unless, indeed, it is the mass of water brought from the South Atlantic by the southeast trades, adding to its volume and to its velocity.

Latitude 43° 30′ *N., longitude* 38° 50′ *W.*—At 4 p. m. on the 15th of July we were on the 80 fathoms! The rod and weight of 230 pounds let go, and as each 100 fathoms ran off the reel it caused some excitement, as at each fathom it was hoped the Bank would be struck; 2,280 fathoms, 13,680 feet, ran out. There was no bank there. The rod brought up "oaze" abounding in animal, vegetable, and mineral.

Here the thermometers were sent down to ascertain specially if cold water existed at any depth. One thermometer burst at 1,400 fathoms. Water was brought up from a depth of 1,500 fathoms, (temperature 42°,) containing small and delicate particles of *Algæ* of various bright colors, showing, probably, that light had penetrated to that depth; but there was not a sign of animal life. The temperature of the air was 77°; the temperature of the sea 73°. At 100 fathoms below it was 62°, or 10° less; at 300 fathoms below 55°, or 20° less; and at 1,000 fathoms it was 42°, or 30° less; so that cold polar waters were passing underneath at 200 fathoms below the surface.

Another sounding for the Bank was tried, and 2,600 fathoms obtained; the rod bringing up from the same vast cemetery countless thousands of its dead, and of the same character as those found a day or two previous at a nearly similar depth, except that the *Globigerinæ* were in clusters, and in those *fractured* there was a hard, compact, crystallized, fine sand.

Notes.

5, 6. (Con'd.) The fractured *Globigerinæ* in this sounding were very beautiful, showing margins of vertical crystal formation, clear as water, the fractured globes or cells containing, apparently, minute quartzose sand. Thinner glass-like forms of air-like globules, in irregular order, were probably *Coccospheres.*

A small convex portion illustrated beautifully the radiating perforations or canals of the *Foraminifera*, both direct and diagonal; and some few irregular particles of diatoms, flexible and multiform.

One young *Globigerina*, in which the cells were quite transparent and thin; none of these have any granular deposits in their interior. Some of these also show the horizontal layers of each wall, added layer to layer, the outer ones thickening, and the external layer becoming coated with tubercules; the interior are of an enamel transparent smoothness.

The heat in the Gulf Stream was found at times very oppressive, and reminded us all of the climate of Trinidad in the wet season. The thermometer in the shade was 82°, in the sun 96°. The warm vapor arising from the heated water made one feel languid, lazy, and sleepy, and was very debilitating.

By the temperatures obtained from actual observation at 300, 500, and 1,000 fathoms, the waters were in all cases warmer than the corresponding depths north of the Gulf Stream. This is, of course, very natural, but it is as well to have it from actual observation; and this would argue in favor of bodies of warm water being brought up from the coast of Africa by the southeast trades, from the coast of Spain by the E. N. E. trades, and, accumulating with those of the Gulf Stream on the position assigned to the Milne Bank, assisting materially in adding to its velocity there.

Stood north again for polar waters, which were soon felt by the temperature of the sea-surface changing in 2½ hours 14°—from 72° to 58°—giving again the northern limits of the Gulf Stream. The air also gave proofs of this again, for in an hour we passed from a close uncomfortable heat to a chilly cold, which compelled all hands to put on warm jackets; and, as a natural consequence of this change, soon followed a dense fog.

Ran for the Flemish Cap, on which we sounded and obtained 80 fathoms. Stones, feldspar, and various-colored quartz, with some few *Foraminifera* even in these shoal waters.

Sounded midway between the north part of the Flemish Cap and the Grand Bank, to ascertain if there were any connection, or if they were separated by a deep channel; 250 fathoms was obtained, showing that it *was* part of the bank, but having a rocky nucleus, about which the soil brought down by the ice accumulates; but the Polar current over it is sufficiently strong to keep the rock bare. On two occasions it bent and turned the iron cup of the weight in 90 fathoms; here, at 250 fathoms, the temperature of the sea was 38°, while at the surface it was 50°, the air being the same. The south part of the Cap is not, however, united to the Banks for 700 fathoms, and no ground was obtained between them.

Latitude 46°.—On the parallel of 46° latitude, at a distance of 25 miles from the edge of the bank, sounded in 1,000 fathoms, bringing up large quantities of rounded particles of quartz of various colors.

Here a section of the slope of the bank was made, showing its ascent, formation, and the nature of these vast banks. From 1,000 fathoms—of colored, quartzose sand, to 650—of silicious spicules of sponges; then to 450—green mud, 150—quartzose sand, 60—stones, 55—stones, sand, and fish bones; and the latter told us that we were on the Grand Banks. **Notes. 5, 6.** (Con'd.)

Passing over and searching for the "Jesse Ryder Shoal" of 4 fathoms, which was found *not* to exist, we put over the dredge and dropped on a perfect colony of star-fish (*Ophiocoma*) of all sizes, from half an inch to three inches in diameter.

In a very dense fog steered for St. John's, Newfoundland, where we arrived on the 24th July, to rest for a few days after the work in the Gulf Stream. It was cold, raw, and foggy; but we were very glad to drop anchor in its snug and secure harbor, free for a while from all the cares, anxieties, and perplexities necessarily attending deep-sea sounding.

Having again prepared lines, instruments, and chronometers for a second voyage, sailed on the 27th August for the north extreme of the Gulf Stream, and which was reached two days afterward, the sea temperature rising suddenly from 53° to 61°.

Latitude 44° 3′ N., longitude 48° 7′ W.—Here soundings were again obtained with rod and heavy detaching weights in 1,650 fathoms, bringing up *Foraminifera* in all stages, whole and fragmentary, having from two to six cells or chambers in clusters, spherical, plate; and flat-shaped *Polycystina*, (diatoms,) with a few spicules of sponges, as well as some *Coccoliths.*

Temperatures of under strata of currents were obtained, again showing that at 1,000 fathoms the water was 39°.5, and at only 50 fathoms below the surface (which was 61°) it was 43°, or 18° colder! air being 61°; another proof of the bare superficial Gulf Stream.

Another cast of the lead on the supposed position of the Sainthill volcano quite disproved the existence of this vigia within a radius of many miles.

We were approaching, for the second time, the Milne Bank, of 80 fathoms; and although 2,300 fathoms was obtained on it a short time since, yet there was still a hope that the second attempt would be more successful, particularly as a telegram had reached me from England to the effect that "there was no doubt of the Milne Bank, as bottom was brought up *three* times;" and indeed so it would appear. But on the 3d of September, (latitude 43° 40′ N., longitude 38° 50′ W.,) the lead was again let go and 2,700 fathoms obtained, the rod bringing up a small but precious particle of *Foraminifera.*

The towing-net gave another rich haul of *Hyalaea—Atlanta* and *Spirula*—with three specimens of *Nautilus cornucopia*, (I believe the latter to be Operculate.) In no case could the remains of those creatures which had lived on the surface be found in the vast cemetery at the bottom; probably long before they reached so great a depth their softer parts had decomposed, and their shells assisted in forming one of the component parts of the ocean, carbonate of lime, or became food for their hungry neighbors, the mollusks. (Toward the end of these investigations I was compelled to alter my opinion on this subject, an interesting sounding having brought up from 2,000 fathoms the shells of those *Pteropods* living on its surface.—W. C.)

It is curious to find how the different species of these delicate ocean-shells have their own special haunts and feeding-grounds. In one place, the *Atlanta* are taken in numbers, with scarcely any others; in another, a net full of *Hyalaea tridenta;* then quantities of *Spinosa* or *Radiata;* lastly, a bag of *Jauthina fragilis;* but these latter are more generally distributed than others. All these are found

Notes.

5, 6. (Con'd.) more numerous on the surface at the sun's rising and setting, and very abundant during light showers of rain.

Near the supposed position of this bank we sounded, at short distances, for some days, with more than a thousand fathoms of line; but in no case was there any indication of this bank. The last effort to sound in 1,000 fathoms, north of this supposed bank, will not easily be forgotten; it was obtained under many and great difficulties. The sea had risen to a fearful height in a very short time, which threatened to roll all the boats from the davits. My steam-cutter, Torch, did start. There was scarcely any standing on the deck. All the thirty-five men on the starboard side, while hauling the line in, lay down, or rather were thrown down on the line.

Latitude 43° 30′ *N., longitude* 38° 5′ *W.*—Sounded again with heavy weights in 2,000 fathoms, bringing up *Foraminifera* in various stages of growth; and what gave interest and value to this sounding was the fact that icebergs had reached these limits, proved by the presence of a piece of stone, three-quarters of an inch in size, deposited undoubtedly there by a berg, and brought up in the valve.

Latitude 43° 43′ *N., longitude* 37° 47′ *W.*—On the 5th of September a sounding was taken at 1,930 fathoms; the rod came up with its spring broken, but retaining sufficient of the bottom to show that it was down. *Foraminifera*, the usual deep-sea characteristic, appeared, mostly young and small, with transparent cells; about 6 per cent. of all these are free from fracture, all the remainder fragments.

Before leaving the vicinity of this supposed bank, the temperatures here obtained, with new and delicate thermometers, at 2,000 fathoms, was 42°—rather a higher temperature than expected. The air was 68°, the sea-surface 69°; while, at 100 fathoms, it had fallen 10°, and at 400, 20°! At 1,000 fathoms it was 43°, after which it fell but 1° in 1,000 fathoms, (showing a great uniformity of temperature after the first 500 fathoms.)

Great quantities of *Salpæ* and *Medusæ* came up entangled with the line, doubtless caught in its quick descent of 500 fathoms in 3½ minutes, (or equal 14 feet in 1 second, which equals 1 mile in 6 minutes.) Their orange-colored stomachs, situated in the center of the transparent gelatinous sacs, came in quite perfect on the line.

Latitude 43° 39′ *N., longitude* 36° 46′ *W.*—On the 6th September we gave our departing and final cast of the lead in this vicinity, getting 2,060 fathoms, the rod bringing up *Foraminifera*, small stones, and some *Diatoms.*

We were now leaving the regions of the *Globigerinæ* and lime-formations, changing them for those of silicious deposit. Nearly all, in this last sounding, were *Diatoms*, with but few *Globigerinæ.* A thermometer was sent down to 2,000 fathoms, and proved the last temperature at the same depth, showing 42°.5.

To complete a series of 100-fathom temperatures, advantage was taken of a fine day with smooth water—both indispensable requisites in sounding for temperatures, as the smallest jerk or vibration moves the indices and the reading is destroyed, the results being only deceptive. The thermometer went down to 1,500 fathoms, and in no instance did it show less than 42°.5, fully proving the high temperatures obtained on former occasions, and this would prove the entire absence of an under Polar current here; and, further, that the waters of the Gulf Stream here mixed with other waters, decreasing thereby its strong easterly set, which was here found, on many occasions, to be variable. The temperature of the surface was 71°. **Notes. 5, 6.** (Con'd.)

From the authority of a few scattered observations, it has been asserted that the water of the ocean, at a depth of 12 feet, was of a higher temperature than at the surface. This was proved to be correct, although remarkable, by 45 carefully-obtained observations, between Halifax and this position. Of these 45 observations, 26 are warmer, 10 are colder, and 9 have the same temperature. The warmer are in favor of the colder, 16° in the whole, but in no one instance greater than 1°.5; and the greatest and most constant are noticeable to the east of the Milne Bank, after the rapid current of the Gulf Stream had been passed.

In the Pacific, off the west coast of America, (the Isalcos Mountains,) the temperature at 12 or 15 feet below the surface has been found to be 10° or 11° higher. This, I presume, is caused simply by excessive evaporation, as I have often found there the difference between the wet and dry-bulb hygrometer to be 9°, and on one occasion 11°.

Latitude 46° *N., longitude* 29° 40′ *W.*—On the 9th of September, being on the position of a vigia, a very satisfactory sounding of 1,650 fathoms was obtained: first disproving the existence of such a danger, and secondly bringing up the most interesting and remarkable specimen of the bottom, showing that those minute creatures which live on the surface do assist in forming the bottom of the ocean; *Foraminifera* and *Diatomaceæ* surrounding six dead *Hyalaea* shells, all perfect. These, to have been taken on the bottom, must have been dead, and for a valve the size of a shilling to have entrapped six of these, they must have been numerous indeed. The whole area of the six was greater than the valve itself; they must, therefore, have been in such quantities as to overlap one another. *Hyalaea* were also taken on the surface in the towing-net; so that here was a successful illustration that these lived on the surface, and were buried, after their period of existence, on the bottom.

This was a shoal sounding compared with those around it, and silicious animal formations now became more numerous; the *Coccospheres* and other delicate forms exactly resembling the *Nautilus*, chambered, but devoid of the syphuncle by which the latter elevates and depresses itself at pleasure, by exhausting or filling its chambers with water. Thirteen chambers were counted in one form.

In this sounding, also, animal remains were seen, and could hardly be mistaken; the feelers, or radiating processes from the tubercles of the canals, were regularly radiating, and at the point where the chambers intersect was a mass of minute spawn-like globules.

Inorganic fragments of some size were also seen, having a smooth, concave impression, intersected with dark lines. In no instance are the shells of the *Hyalaea* taken alive on the surface, so large as those found dead on the bottom; so that it may be possibly inferred that they have died at their full growth, at the limit of their permitted existence.

A very interesting and valuable sounding was made about 180 miles E. N. E. of the last, in 1,180 fathoms, showing a less depth of water, by 200 fathoms, than in any part of the Atlantic, (not approximate to the shore.) A small portion of the bottom "oaze" came up, attached to a pig of ballast which was the weight used on this occasion.

Latitude 47° 11′ *N., longitude* 23° 14′ *W.*—On the 12th September the favorable weather, with a dead calm, induced us to sound, and a cup-lead of 112

Notes.

5, 6. (Con'd.) pounds reached the bottom at 2,000 fathoms, bringing up a full cup of pale cream color "oaze" *Infusoria*, like ice-cream, and quite as cold. In this sounding were many-shaped and various-formed *Globigerinæ*, hemispherical and globular; also many spheroidal organisms, in one specimen of which we counted thirteen chambers.

A fractured portion of a *Globigerina* cell showed that the interior wall was formed of perpendicular, transparent, four-sided cells, while the exterior was perforated by narrow canals, running perpendicular to the frame. The temperature at that depth was still 42°.

Our sounding had now ceased, and this novel and interesting work had finished.

It is worthy of remark that the general character of all these thirteen soundings, varying in depth from 80 to 2,700 fathoms, spreading over an area of upwards of 10,000 square miles, from Sable Island to the Azores, shows a remarkable uniformity, both in respect of temperature and sea-bottom. One chief object throughout was to ascertain if, in any of these organized forms, animal life still existed. They were placed, for fourteen days, under a powerful microscope, and in no one instance was either animal life or animal remains visible, except in the two doubtful instances recorded. Therefore it may be safely concluded that these minute creatures do not live where found, at the bottom of the ocean.

Hundreds of the animal organisms of *Foraminifera*, *Globigerinæ*, *Coccoliths*, &c., with which the soft light-brown and yellow mud abounded, were, after being diluted with clear water, separated from the muddy particles and broken under the lens with a finely-pointed penknife. It required some force to break them, and the sharp shock and cracking was plainly perceptible; in no single instance was life or movement visible.

The mud, when dry, is either of a pale yellow marl, light-brown, or greenish-brown color; the former containing chiefly *Globigerinæ* or calcareous formations, the second silicious or *Diatomaceæ*, and the last silicious spicules of sponges. All are apparently soft mud until rubbed between the fingers, when gritty particles are detected. These are the *Globigerinæ*, in great variety of shapes and numbers, some being formed in concentric layers round a transparent center.

In the deepest waters and most distant from land were the greatest numbers of perfect specimens of *Globigerinæ* found, in soundings 12 and 13; and as the water decreased in depth and neared irregularities, so they became fragmentary. These facts suggest that, either at the lesser depth some wave-movement, or, may be, current, fractured these delicate organisms, or that their cases were broken by mollusks, or other devouring agents for the softer matter in the interior, and the shelly portions then allowed to descend to the bottom.

With many experiments in water, it was found that not only were the *Globigerinæ* of much more specific gravity than the water, but that they sunk with a rapidity truly wonderful and invariably with the convex side downward, and in that position (which was contrary to which they lived) remained so.

In passing the soundings a second time under the microscope, some new forms were detected, which will be seen in the drawings; and these are, for the most part, of silicious formation, some having a thin, irregular, and broken coating of lime; others as transparent as glass.

The thin membrane-lining in some of the *Globigerinæ* were also noticed, but these could hardly be the remains of the once living animal. Notes. 5, 6. (Con'd.)

Some recent *Globigerinæ*, which appeared discolored, (a light red,) were broken; but no minute granules were inside.

In the second examination of the *Globigerinæ*, I was compelled to alter my views with regard to the rounded aperture, (which I thought may be formed by an annelid,) but which I found in every form, larger or smaller, according to age and size. In some instances the apertures were in the *two* last chambers, the lips of which were smooth and rounded off with a transparent glass-like finish.

The CHAIRMAN, in inviting a discussion on the papers, remarked that there were two distinct matters for consideration. One was the hydrography of the Gulf Stream, and the other the general question of submarine geography. Both subjects were of great interest, and he hoped they would both receive elucidation that evening. He was afraid that many of the Fellows, like himself, had so grown up in the belief that the temperature of our country was affected by the Gulf Stream, that they would find a difficulty in doubting it. Nevertheless, Mr. Findlay's arguments tended to shake that belief. Still, he should like to hear the cause of the peculiarly mild temperature of the West of England explained. If it were due merely to currents of wind, he would have thought the same mildness might have been perceptible far more inland than it was. He hoped that, as Professor Huxley, one of the first authorities in England on all questions of submarine animal life, was present, he would be kind enough to state his views with reference to these interesting forms of animal life, some of which had been brought up from a depth of 2,700 fathoms. Submarine geography was not merely interesting in that point of view, it was also a practical question. Geographers ought to obtain as accurate a knowledge of the surface of the globe under the sea as they possess of the surface of the globe above the sea. The deep-sea soundings that were now being carried on in different parts of the globe had the object of ultimately arriving at such a knowledge. It was not until we possessed this knowledge that we should be able to traverse the oceans with telegraph cables, for there was no reason why we should not lay down submarine lines in all directions with the same facility that we now employed aërial telegraphs. As a contribution to this, he regarded Lieutenant Chimmo's paper as meriting great consideration.

Captain SHERARD OSBORN, R. N., said Lieutenant Chimmo's paper was a most valuable addition to our knowledge. Previous to his soundings off the southern extremity of the Newfoundland Bank, the Gulf Stream, in that quarter, was reported to be unfathomable. Lieutenant Chimmo had sounded to the bottom on every occasion he attempted but one, and then probably the bight of his line was carried away by currents. Moreover, by careful observation, he had disposed of a very alarming feature which was said to exist in mid-ocean—the Milne Bank, named after the gallant officer who was said to have discovered it. It was a pleasant thing to be assured that no such bank existed, and for this they were indebted to Lieutenant Chimmo. He had, moreover, confirmed our previous knowledge respecting the level of the ocean bed, between the coasts of Europe and those of America. We might take the mean depth to be about 2,000 fathoms, across the North Atlantic Ocean. And he had disposed of the theory that the Gulf Stream had an enormous scooping effect, wearing a deep

Notes.

5, 6. (Con'd.) furrow in the sea-bottom. As Mr. Findlay had shown, its depth might be limited, as far as the warm water indicated. But he himself did not see why the stream should be limited to warm water—why it should not combine both hot and cold. He still believed in the existence of the Gulf Stream, from the enormous quantity of wood and drift that he had noticed far away to the north; and he believed that the Gulf Stream did ameliorate our climate very considerably; that the mildness of our climate was owing, not merely to the effects of warm air, but to the effects of water of a high temperature as well. There were very few sailors acquainted with the sea between the Azores and the Land's End, who had not noticed tropical species of fish accompany drift-timber there. Wherever we found the dolphin and other fishes of warm seas, we might be sure that the temperature of the water was pretty much the same that it was in the tropics. Then there were many other streams of a similar character in different parts of the globe. There was that remarkable stream on the east coast of Africa which flowed from Cape Guardafui for 2,000 miles, almost into the harbor of Bombay. That had recently been explored by an officer in our service, and he had obtained soundings throughout its whole length. There was a similar stream, called the Black Stream, between China and Japan, which was just as marked at the edge as the Gulf Stream. Beyond this there was little or nothing known of it; he did not believe it had been sounded, or that its limits had been marked. All these streams ran parallel to each other, nearly from southwest to northeast; they formed three great oceanic streams, as it were, which flowed through the wastes of ocean with outlines as marked as the Mississippi or the Orinoco. Here was an immense field laid open to the investigation of the hydrographer; and he only hoped that members of his profession, while the sword was laid aside, would, encouraged by our Society, throw their enterprise and intelligence into so promising a field of discovery and usefulness.

Professor HUXLEY said no naturalist, who had looked broadly at his subject, could fail to be greatly interested in physical geography; no man could have a conception of the bearing of a great many most important biological facts who had not paid very considerable attention to this department of science, and to all those great features of oceans and rivers which were either the causes or the effects of the phenomena of physical geography. He proposed, therefore, to make remarks on the two subjects submitted to their consideration that evening—the Life of the Sea-bottom, and the Gulf Stream.

With regard to the deep-sea soundings which Lieutenant Chimmo had described, speaking with every respect for the zeal and high intelligence which that gentleman had displayed in his observations, and knowing partially how difficult it was to make such observations while at sea, he still might be permitted to remark that they made no substantial addition to what had already been established by a considerable number of observers, with regard to the character of the Atlantic sea-bottom. In some respects he ventured to think—having been favored by the Hydrographer to the Admiralty with the particular soundings that Lieutenant Chimmo had brought home—that he had not quite clearly interpreted the facts. There could be no doubt that animal remains were contained in a very large portion of the *Globigerinæ* shells. By proper methods of treatment, by dissolving them in acids, you may get out the soft bodies. Not only so, but Professor Frankland, to whom he had submitted portions of such soundings, had determined, by the process of organic analysis, the existence of more than 1½ per cent. of organic matter in these soundings; which 1½ per cent. of organic matter could be clearly identified by the microscope in two shapes—in part as *Globigerinæ* shells, in part as a confused network of simple organisms, distinct from the *Globigerinæ*—one of the most remarkable of simple organisms, to which he had given the name of *Bathybius*. That simple organism, one of the simplest forms of animal life, we now know covered the whole area of the North Atlantic in all the regions that have yet been surveyed. The very admirable soundings in the Indian Ocean which had been made by Captain Shortland, to which Captain Sherard Osborn referred, had enabled him to extend his knowledge of that organism. From the Arabian Gulf, at a depth of 2,800 fathoms, along the whole of the east coast of Africa, round the Cape of Good Hope, and along the west coast until it joined the North Atlantic again, he could trace, throughout the whole extent, at these prodigious depths, that that sea-bottom was covered with a network of organic matter. There could be no sort of doubt that living animals exist at the bottom of the deepest seas yet explored. How they lived there, how they acquired their store of food, was one of the most curious questions of organic chemistry, one which we could not solve at present. But it was the fact that there were two distinct constituents in this Atlantic mud: one of them like the organisms which he had described and the *Globigerinæ* living on the sea-bottom, and the other siliceous remains of organisms living near the surface, and which only reached the bottom after they died, for their skeletons had sunk down through the great depth of sea-water and mixed with the living creatures at the bottom. He looked upon those two results as now definitely acquired to science. He might remark, perhaps, in reference to something which was let fall by Captain Osborn, that, as far as he had been able to examine the deep-sea soundings from the Arabian Gulf, the character of the bottom was, in the main, very similar to that of the great Atlantic plateau. Over most parts of it the sticky, adhesive *Globigerina* mud exists in large proportion, and in certain parts *Globigerinæ* are replaced by an excessively fine and attenuated sand. But in all the specimens which had been brought up by Lieutenant Chimmo there was an entire absence of everything but the very finest and softest calcareous or siliceous matter.

Notes. 5, 6. (Con'd.)

With regard to the hydrographic question of the extent of the Gulf Stream, he had listened with great attention to the facts and argument which had been brought forward by Mr. Findlay, and he must confess he had arrived at two results unfavorable to the purport of the paper. The first was that he did not find in the statements brought forward any facts not to be met with in the works of Maury; and still more particularly in that excellent essay upon the Gulf Stream which was published a year or two ago by Mr. Kohl, and to which he would recommend every one who took a particular interest in the subject for a perfect plethora of facts connected with the phenomena of the Gulf Stream. The second conclusion was that the arguments which had been brought forward did not seem to justify the important conclusion arrived at. Indeed, he thought a considerable amount of fallacy lurked in those arguments. Mr. Findlay drew attention to the very small extent of the Gulf Stream between the peninsula of Florida and Cuba; and he asked the question, how was it credible that so small a volume of water as this should give rise to the great mass of warm water which was found taking a northeastern and easterly course in the northern part

Notes.

5, 6. (Con'd.) of the Atlantic? Now, if the velocity of the water which passed through the Straits of Florida were the same as the velocity of the water in the region of Newfoundland, that query would have considerable force. But it seemed to him to fail, unless we took into account the fact that the velocity of the water passing through the Straits of Florida was three or four times greater than that of the stream in the North Atlantic. These facts regarding the Gulf Stream had been well established by the careful observations and surveys of the American Navy; and he must say it was a disgrace to this country that, with our vast naval resources, we could not produce anything to compare with these great American surveys. But, leaving that aside as a mere incident in the question, he would say that the consideration of relative velocity is one of great importance in view of the difficulties put before us. Another argument which he would bring against Mr. Findlay's conclusions was based upon the very admirable map of the Gulf Stream, published last year by the Hydrographer of the Admiralty. Every one who knew that map would say it was a document of extreme value, a first-rate authority; and in that map the currents continuous with those of the Gulf Stream were traceable, with diminished velocity, to the northern points of the coast of Scotland. He did not think any one who looked at that map, and traced out the gradual diminution of that stream, could have any doubt that he was dealing with a phenomenon that had one and the same cause. Another argument quoted by Mr. Findlay from another author was so singularly at variance with what we knew of ordinary physical laws, and with what was very well known with regard to the Gulf Stream in particular, that it could not stand its ground for a moment. It had been suggested that this easterly trend of the Gulf Stream was due to the Earth in the northern part of America shunting it on as it turned round.

Mr. FINDLAY. It was Mr. Leighton Jordan's argument.

Professor HUXLEY. The argument of Mr. Leighton Jordan appeared to be that the water, not partaking fully of the movement of the Earth, was, so to speak, shunted on to the eastward by the action of the eastern side of North America. In any case, an explanation of that kind could not possibly apply. We all knew, as a matter of physics, that the water at the Equator partook of the motion of the Earth at the Equator. It consequently had a greater velocity from west to east than the surface of the Earth in more northern latitudes. We also knew, in accordance with the ordinary laws of physics, that if that mass of water were transferred northward, it would, for a considerable time, keep its primitive velocity. The consequence would be that, as it traveled from west to east faster than the Earth was traveling in a corresponding latitude, it would trend away to the eastward; so that, so far from the land forcing the water to the eastward, it was the water that trended to the eastward, leaving the Earth behind it.

Mr. FINDLAY thought his arguments had been misunderstood. He had carefully calculated the velocity of the Gulf Stream at its initial point, and the amount of water carried forward day by day. The velocity was exceedingly well known. Its annual mean and its monthly mean were also very well known. The stream took 25 days to reach Nantucket, 50 days to reach the Newfoundland Bank, and 200 days to reach the western coast of Europe. From its known sectional area between Florida and Cuba, he contended it was impossible such a stream could spread over the whole of western Europe up to Iceland, as far as the northern coast of Norway and Spitzbergen, and to other places where there was a comparatively mild climate. He repeated, such a body of water passing from the Gulf could not produce those effects on the climate of the whole of western Europe without being aided by some other causes. Then there was the fact that the warmest point of the Gulf Stream was on its western edge, the warmest water being pressed upon the American coast, along which the Polar Current was running south. He wanted to know why that was? why the warmth should not be diffused more to the eastward? It was only a suggestion of Mr. Leighton Jordan that the axial rotation of the Earth might account for the phenomenon in some degree. But, apart from that, he would contend that that small body of water would never cover the whole of the west coast of Europe; it was the great winds which blew from the southwest in that part of the Atlantic that produced a drift toward the coasts of Europe. Moreover, there was the drift of water round the Bahama Bank, which joined the Gulf Stream. The Gulf Stream, in fact, could form only a fractional portion of the circulation. **Notes. 5, 6.** (Con'd.)

The CHAIRMAN, in closing the discussion, said that the great point was to bring men of science and practice together, for truth was elicited by the efforts of the two. He was much indebted to Professor Huxley for giving him the chance of still indulging in those ideas that he had always entertained with regard to the effect of the Gulf Stream upon our climate. He must say he did not think that Mr. Findlay had absolutely dissipated that belief.

[In the sitting of the Royal Geographical Society, of May 10, 1869, the following letter of Rear-Admiral Irminger was read, bearing upon the subject of the above discussion. (Proceedings vol. xiii, p. 226.)—HYDROGRAPHIC OFFICE.]

COPENHAGEN, *April* 21, 1869.

I have read with the greatest interest the discussions in the Royal Geographical Society, at the Meeting, February 8, between Mr. Findlay, Captain Sherard Osborn, R. N., and Professor Huxley, concerning the Gulf Stream.

For nearly thirty years I have, partly myself, partly through naval friends and intelligent ship-masters, who with me take interest in oceanic currents, made observations on currents and temperatures, chiefly of the Northern Atlantic Ocean. I have always, nearly every year, furnished them with well-corrected thermometers; and these observations on the water which comes from more southerly and more heated parts of the Atlantic, and also on the waters of what I believe to be the Gulf Stream, I take the liberty of submitting to the Royal Geographical Society.

The chart which I send [which was exhibited to the Meeting] shows the temperatures between Shetland and Greenland, and the accordance existing between the many annual observations in my possession, of which I have only marked the temperatures for a few years.

According to these observations it can be said, with certainty, that the current in the Northern Atlantic flows toward the north, even up to the Icy Sea.

In a treatise on currents of the ocean (Havets Strömninger; Nyt Archiv for Sövæsenet, 1853) I have published the observations, made with all possible accuracy, in one part of the North Atlantic, by seven of our men-of-war, provided with superior chronometers and other instruments; and a medium of these observations in different years gave:

Notes.

5, 6. (Con'd.) Between 59° 30′ and 61° 30′ latitude N., and 2° and 6° longitude W. of Greenwich, in 17 days,* the current was found 4.7 nautical miles per day, N. 72° E. true.

Between 60° 0′ and 62° 0′ latitude N., and 6° 0′ and 10° 0′ longitude W. of Greenwich, in 11 days, 2.5 nautical miles per day, N. 60° E. true.

Between 60° 30′ and 62° 30′ latitude N., and 10° 0′ and 14° 0′ longitude W. of Greenwich, in 18 days, 0.8 nautical mile per day, N. 32° E. true.

Between 61° 0′ and 63° 0′ latitude N., and 14° 0′ and 18° 0′ longitude W. of Greenwich, in 25 days, 3.1 nautical miles per day, N. 47° E. true.

Between 62° latitude N. and the south coast of Iceland, and 18° and 23° longitude W. of Greenwich, (nearly the longitude of Cape Reikianäs, the southwest cape of Iceland,) in 32 days, 1.91 nautical mile per day; N. 33° W. true.

Between Fairhill and Greenland the weather was frequently unfavorable for observations for correcting the longitude, but still a constant drift, or slow current of the ocean to the north was observed, and the mean of observations between 32° and 39° W. of Greenwich gave 3.2 nautical miles per day, N. This drift of the ocean in a northerly direction toward the coast of Greenland is besides observable in the temperature of the water.

This drift, or slow current, in the Atlantic is the cause why the harbors of Norway, even farther than North Cape, and as far as the Fiord of Varanger, are accessible for navigation during the whole year; just as the warm current, which passes Cape Reikianäs and runs to the northward along the western shores of Iceland, is the cause of the south and west coasts of this island being clear of ice, so that, even during the severest winters, ships may go to Havne Fiord and other places in the Faxe Bay of Iceland, where they always will be sure of finding open sea. If this current to the north in the Atlantic did not exist, the ice from the sea around Spitzbergen would float down to far more southern latitudes than is now the case; and certainly the coasts of Norway, as well as the sea between Shetland and Iceland, would frequently be filled with ice from the Icy Sea, and the influence of the ice would then be felt on the climate of the neighboring coasts. But this is not the case; and we know that the ice from the Icy Sea (Greenland-ice) only can force its way to the southward between Iceland and Greenland, along the east coast of Greenland, rounding Cape Farewell, and afterward passing Labrador, Newfoundland, and farther south.

Along the north coast of Iceland the current is usually to the eastward, and along the east coast predominating to south; and I think these currents may be considered as eddies of the principal currents in the Icy Sea and the Atlantic.

The current and the ice-drift of the Greenland-ice are sometimes so considerable, that not only the sea between Cape North of Iceland and Greenland is blocked up with ice, but it also strikes against the north coast of Iceland between Cape North and the Bay of Skayestrand, and then, favored by the said eddies, closes the north and east coast of Iceland entirely. On the 24th of May, 1840, this ice was met with even about 100 nautical miles from the east coast. Still this ice never remains on these coasts later than the month of August, but generally leaves earlier, and then swings round in a northeast direction to the Icy Sea again.

---

*I reckon a day = 24 hours.

Notes. 5, 6. (Con'd.)

The temperature of the sea seems to prove that the warmer current of the Atlantic approaches as well the east as the north coast of Iceland more in summer than earlier in the year.

It happens, notwithstanding, that a small part of that ice which now and then incloses the east coast is, by gales from north and northeast, carried to the south shore of the island; but as soon as it appears here it is carried away again with the northwesterly current from the Atlantic, passing Cape Reikianäs, and thus onward to the other ice, constantly blocking up the east coast of Greenland.

The inclosed description* of the currents and ice-drifts near Iceland will give more detailed information for those who may wish it; but I must observe expressly that the ice which now and then incloses the above-mentioned coasts of Iceland never is met with in lower latitudes, as would be the case if the current or drift of the Atlantic were not toward the north.

By studying the temperature of the North Atlantic between Shetland and Cape Farewell, it will be observed that *streaks of warmer water* are found here, some of which I have indicated on the appended sketch. These warmer streaks are not to be found every year in the same longitude, and I think they have their origin from the Gulf Stream, which has retained this higher temperature, and that these warmer streaks, sometimes met with more easterly, or at others more westerly, possibly may be caused by the pressure of the current coming from Labrador, passing Newfoundland, &c., where this current influences more or less the limits of the Gulf Stream, causing its heated water to be inclined sometimes more easterly, and at other times more westerly. Severe gales might likewise possibly have an influence on this deviation.

These warmer streaks, combined with the different tropical products constantly thrown on the shores of Norway, the Faroe Isles, Iceland, Greenland, &c., I believe also to be a proof that the Gulf Stream sends its waters far to the north.

Among the tropical products frequently found is the bean of the *Mimosa scandens*, one of which I send you, and which I found on the shores of Iceland. Near Husavik (North Iceland) I once picked up on the beach so large and fine a specimen of this mimosa that I had a snuff-box made of it.

The inclosed description of the currents will show that Captain Södring, in the Fox, (the same vessel which Captain Sir Leopold McClintock commanded on the Franklin expedition,) on the 7th of March, 1860, in 66° 21′ latitude N., and 1° 26′ longitude W., found the water on its surface, after the long winter's influence in these cold climates, still at 4° R., or 41° F.

With all these facts it appears to me that the Gulf Stream can be followed through the Northern Atlantic, even up to the Icy Sea.

I have limited myself to the above short report, as many distinguished Fellows of the Royal Geographical Society are so well acquainted with the currents of the ocean that I find it superfluous to add more circumstantial details concerning this matter.

Most respectfully,

C. IRMINGER,
Rear-Admiral Royal Danish Navy.

---

*"Strömninger og Iisdrift ved Island:" a printed pamphlet, now in the library of the Society.—[Ed.]

Notes.
7, 8. [7 and 8] Nature, March 24, 1870, p. 540; and March 10, 1870, p. 490.

[These are references to a lecture delivered by Dr. W. B. Carpenter at the British Royal Institution. As this lecture bears throughout on the system of North Atlantic currents, it is added entire. A table of the deep-sea soundings and temperatures discussed in the lecture will be found on page 73 of this volume.—HYDROGRAPHIC OFFICE.]

On the Temperature and Animal Life of the Deep Sea. By Dr. William B. Carpenter.

I.

The present discourse embodies the most important general results obtained by the exploration of the deep sea in the neighborhood of the British Isles, carried on, during the summer of 1869, in H. M. surveying vessel Porcupine, with the view of completing and extending the inquiries commenced in the Lightning expedition in 1868.

The expedition of the Porcupine was divided into three cruises. The first of these, which was placed under the scientific charge of Mr. J. Gwyn Jeffreys, F. R. S., accompanied by Mr. W. L. Carpenter as chemical assistant, commenced from Galway near the end of May, and concluded at Belfast at the beginning of July. It was directed in the first instance to the southwest, then to the west, and finally to the northwest as far as the Rockall Bank. The greatest depth at which temperature-sounding and dredging were carried on in this cruise was 1,476 fathoms; and these operations, through the excellent equipment of the Porcupine and the skill of her commander, Captain Calver, were so successfully performed, that it was confidently anticipated that still greater depths might be reached with an equally satisfactory result.

The second cruise, which was under the scientific charge of Professor Wyville Thomson, F. R. S., with Mr. Hunter as chemical assistant, was consequently directed to the nearest point at which a depth of 2,500 fathoms was known to exist, viz, the northern extremity of the Bay of Biscay, about 250 miles to the west of Ushant. In this cruise temperature-sounding and dredging were carried down to the extraordinary depth of 2,345 fathoms, or nearly three miles—a depth nearly equal to the height of Mont Blanc, and exceeding, by more than 500 fathoms, that from which the Atlantic cable was recovered. This sea bed, on which the pressure of the superincumbent water is nearly three tons for every square inch, was found to support an abundance of animal life; about one and one-half hundred-weight of "Atlantic mud," chiefly consisting of *Globigerinæ*, having been brought up in the dredge, together with various types of higher animals, Echinoderms, Annelids, Crustaceans, and Mollusks; among them a new Crinoid, referable, like the *Rhizocrinus*—whose discovery by Mr. Sars, jr., had been the starting point of the present inquiry—to the *Apiocrinite* type which flourished during the oolitic period.

The third cruise was under the scientific charge of the speaker, with Mr. P. H. Carpenter as chemical assistant; but he had the great advantage of being accompanied by his colleague, Professor Wyville Thomson, who, as in the Lightning expedition, took the entire superintendence of the dredging operations. The object of this cruise, which commenced in the middle of August and terminated in the middle of September, was a more thorough exploration of the area between the north of Scotland and the Faroe Islands, which had been found in the Lightning expedition to afford results of peculiar interest in regard alike to the inequality of temperature and to the distribution of animal life on the sea-bed, which here ranges between the comparatively shallow depths of from 350 to 650 fathoms, the last named being the greatest depth to which dredging had been carried in 1868. Notes. 7, S. (Con'd.)

The weather, during nearly the whole of the Porcupine expedition, was as favorable to its work, as during the greater part of the Lightning expedition it had been unfavorable; and the results obtained not only far exceeded the most sanguine expectations of those who had promoted it, but may be said, without exaggeration, to be such as no previous scientific exploration of so limited an extent and duration is known to have yielded.

The results of the temperature-soundings will be first stated, with their bearing on the doctrines advanced in the former discourse, as probable inferences from the observations made during the Lightning expedition. These observations indicated that two very different submarine climates exist in the deep channel which lies E. N. E. and W. S. W. between the north of Scotland and the Faroe Banks; a minimum temperature of 32° having been registered in some parts of this channel, while in other parts of it, at the like depths, and with the same surface temperature, (never varying much from 52°,) the minimum temperature registered was never lower than 46°, thus showing a difference of 14°. It could not be positively asserted that these minima are the bottom-temperatures of the areas in which they respectively occur; but it was argued that they must almost necessarily be so: first, because it is highly improbable that sea water at 32° should overlie water at any higher temperature which is specifically lighter than itself, unless the two strata have a motion in opposite directions, sufficiently rapid to be recognizable; and, secondly, because the nature of the animal life found on the bottom of the cold area which consists of quartzose sand, and including volcanic particles, exhibited a marked correspondence with its presumed reduction of temperature; while the sea-bed of the warm area is essentially composed of *Globigerina*-mud, and the animal life which it supports is characteristic of the warmer-tempered seas.

This conclusion, it is obvious, would not be invalidated by any error arising from the effect of pressure on the bulbs of the thermometers; since, although the actual minima might be, as was then surmised, from 2° to 4° below the recorded minima, the difference *between* temperatures taken at the same or nearly the same depths would remain unaffected.

The existence in the cold area of a minimum temperature of 32°, with a fauna essentially boreal, could not, it was argued, be accounted for in any other way than by the supposition of an under-current of Polar water coming down from the north or northeast; while, conversely, the existence in the warm area of a minimum temperature of 46°, extending to 500 or 600 fathoms' depth, in the latitude of 60°, (being at least 8° above its isotherm,) together with the warmer-temperate character of its fauna, seemed equally indicative of a flow of equatorial waters from the south or southwest.

It was further urged that, if the existence of two such different submarine climates in close proximity can only be accounted for on the hypothesis of an Arctic Stream and an Equatorial Stream running side by side, (the latter also spreading over the former, in consequence of its lower specific gravity,) these streams are to be regarded (like the Gulf Stream) as particular cases of a great general oceanic circulation, which is continually bringing the water cooled-down in the Polar

Notes.

7, S. (Con'd.) regions into the deepest parts of the Equatorial ocean-basins, while the water heated in the Equatorial regions moves toward the Poles, on or near the surface. Such a circulation was long since pointed out to be as much a physical necessity as that interchange of *air* between the Equatorial and Polar regions which has so large a share in the production of winds; but, while physical geographers remained under the dominant idea that the temperature of the deep sea is everywhere 39°, they could not fully recognize its importance.

These doctrines have been fully tested by the very numerous and careful temperature-soundings taken in the Porcupine expedition; and the result has been not merely to confirm them in every particular—so that they may now take rank as established facts—but also to show that a temperature 2½° below the freezing-point of fresh water may prevail over the sea-bed in a region far removed from the polar, and that even this extreme reduction is by no means antagonistic to the existence of animal life in great variety and abundance.

All the temperature-soundings of the Porcupine expedition were taken with thermometers protected from the effects of pressure by the inclosure of the bulb of each instrument in an outer bulb, sealed around the neck of the tube, about three-fourths of the intervening space being filled with spirit, but a small vacuity being left, by which any reduction in the capacity of the outer bulb is prevented from communicating pressure to the inner. This plan of construction, which was suggested by Professor William A. Miller, has been so successfully carried into practice by Mr. Casella, that thermometers thus protected have been subjected to a pressure of three tons to the square inch, in a testing-machine devised for the purpose, without undergoing more than a very slight elevation, of which a part, at least, is attributable to the heat given out by the compression of the water in which they were immersed; while the very best thermometers of the ordinary construction were affected by the same pressure to the extent of 8° or 10°, the elevation in some instruments reaching as much as 50° or 60°. Two of these protected Miller-Casella thermometers were used in each observation, and they always agreed within a fraction of a degree. The same pair were used throughout the expedition, and notwithstanding that they were used for 166 separate observations, in which they traveled up and down nearly 100 miles, they came back in perfectly good order, a result mainly due to the care with which they were handled by Captain Calver. It may be affirmed, with great confidence, that the temperatures which they indicated were correct within 1°, (F.,) an approximation quite near enough for the scientific requirements of the case.

In order to connect the work of the Porcupine with that of the Lightning expedition, it will be desirable to commence with the third cruise of the former, in which a detailed survey was made of the area traversed in the preceding year by the latter. In this cruise bottom-soundings were taken at 36 different stations, at depths varying from 100 to 767 fathoms; of these 17 were in the cold area and 14 in the warm, while 5 exhibited intermediate temperatures, in accordance with their border position between the two. In order to ascertain whether the minimum temperatures thus obtained were really the temperatures of the bottom, serial soundings were taken at three stations, of which one was in the warm area and two in the cold, the temperature at different depths between the surface and the bottom being ascertained by successive observations at the same points, at intervals of 50 or 100 fathoms. All these results agreed extremely

Notes. 7. S. (Con'd.)

well with each other; and they closely accorded with the 15 observations made in the Lightning expedition, when the requisite correction for pressure (from 2° to 3°, according to the depth) was applied to the latter.

The following general summary of these results brings into marked contrast the conditions of the warm and cold areas, which occupy respectively the W. S. W. and the E. N. E. portions of the channel between the north of Scotland and the Faroe Islands, and lie side by side in its midst.

The surface-temperature may be said to be everywhere nearly the same, viz, 52°; the variations above and below this being attributable either to atmospheric differences, (as wind, sunshine, &c.,) or to difference of latitude. Alike in the warm and the cold areas, there was a fall of from 3° to 4° in the first 50 fathoms, bringing down the temperature at that depth to 48°. A slow descent took place nearly at the same rate in both areas through the next 150 fathoms, the temperature in the warm area, at the depth of 200 fathoms, being 47°, while in the cold it was 45°.7. It is below this depth that the marked difference shows itself; for, while in the warm area there is a slow and pretty uniform descent in the next 400 fathoms, amounting to less than 4° in the whole, there is, in the cold area, a descent of 15° in the next 100 fathoms, bringing down the temperature, at 300 fathoms, to 30°.8. Even this is not the lowest; for the serial soundings, taken at depths intermediate between 300 and 640 fathoms, (the latter being the greatest depth met with in the cold area, midway between the Faroe and the Shetland Islands,) showed a further progressive descent, the lowest bottom-temperature met with being 29°.6. Thus, while the temperature of the superficial stratum of the water occupying the cold area clearly indicates its derivation from the same source as the general body of water occupying the warm area, the temperature of the deeper stratum, which may have a thickness of more than 2,000 feet, ranges from the freezing point of fresh water to 2½° below it. Between the two is a stratum of intermixture, of about 100 fathoms thickness, which marks the transition between the warm superficial layer and the body of frigid water which occupies the deeper part of the channel.

The shortest distance within which these two contrasted submarine climates were observed at corresponding depths was about 20 miles; but a much smaller distance was sufficient to produce it when the depth rapidly changed. Thus, near the southern border of the deep channel, at a depth of 190 fathoms, the bottom-temperature was 48°.7; while only 6 miles off, where the depth had increased to 445 fathoms, the bottom-temperature was 30°.1. In the first case the bottom evidently lay in the warm superficial stratum; while, in the second, it was overflowed by the deeper frigid stream.

It seems impossible to account for these phenomena on any other hypothesis than that of the direct derivation of this frigid water from the Arctic basin. And this agrees very well with other facts observed in the course of the exploration. Thus, first, the rapid descent of temperature, marking the "stratum of intermixture," began about 50 fathoms nearer the surface in the most northerly portion of the cold area examined, than it did in the most southerly, as might be expected from the nearer proximity of the cold stream to its source; second, the sand covering the bottom contains particles of volcanic minerals, probably brought down from Jan-Mayen or Spitzbergen; third, the fauna of the cold area has a decidedly boreal type, many of the animals which abound in it having been hitherto found only on the shores of Greenland, Iceland, or Spitzbergen.

Notes.
7, 8.
(Con'd.)

Although the temperatures obtained in the warm area do not afford the same striking evidence of the derivation of its whole body of water from a southern source, yet a careful examination of its condition seems fully to justify such an inference; for the water, at 400 fathoms, in latitude 59½°, was only 2°.4 colder than water at the same depth at the northern border of the Bay of Biscay, in a latitude more than 10° to the south, where the surface-temperature was 62°.7; and the approximation of the two temperatures is yet nearer at still greater depths, the bottom-temperature, at 767 fathoms, at the former stations, being 41°.4, while the temperature at 750 fathoms, at the latter point, was 42°.5. Now, as it may be certainly affirmed that the lowest temperature observed in the warm area is considerably above the isotherm of its latitude, and that this elevation could not be maintained against the cooling influence of the Arctic Stream but for a continual supply of heat from a warmer region, the inference seems inevitable that the bulk of the water in the warm area must have come thither from the southwest. *The influence of the Gulf Stream proper*, (meaning by this the body of superheated water which issues through the "Narrows" from the Gulf of Mexico,) *if it reaches this locality at all—which is very doubtful—could only affect the most superficial stratum; and the same may be said of the surface-drift caused by the prevalence of southwesterly winds*, to which some have attributed the phenomena usually accounted for by the extension of the Gulf Stream to these regions. And the presence of the body of water which lies between 100 and 600 fathoms depth, and the range of whose temperature is from 48° to 42°, can scarcely be accounted for on any other hypothesis than that of a great general movement of Equatorial water toward the Polar area; of which movement the Gulf Stream constitutes a peculiar case, modified by local conditions. In like manner, the Arctic Stream, which underlies the warm superficial stratum in our cold area, constitutes a peculiar case, modified by the local conditions, to be presently explained, of a great general movement of Polar water toward the Equatorial area, which depresses the temperature of the deepest parts of the great oceanic basins nearly to the freezing-point.

II.

During the first and second cruises of the Porcupine the temperature of the eastern border of the great North Atlantic basin was examined at various depths, between from 54 to 2,435 fathoms, and in widely different localities, ranging from latitude 47° to latitude 55°. The bottom-temperature was ascertained at 30 stations, and serial soundings were taken at 7 stations, making the total number of observations 84. Among all these the coincidence of temperatures at corresponding depths is extraordinarily close, the chief differences showing themselves in the temperature of the surface and of the stratum immediately beneath it. A decided superheating is observable in this superficial stratum, not extending to a depth of much more than 70 or 80 fathoms, and more considerable at the southern than at the northern stations. *Whether this "superheating" is entirely due to the direct influence of solar heat, or depends, in any degree, on an extension of the Gulf Stream*, as far as the southern part of the area examined, is a question which can only be resolved by the determination of its relative amount at different seasons. Between 100 and 500 fathoms the rate of decrement is very slow, averaging only about 3° in the whole, or three-fourths of a degree for every 100 fathoms; and this body of water has a temperature so much above the isotherm of the northern stations, at which the observations were made, as decidedly to indicate that it must have found its way thither from a southern source. Between 500 and 750 fathoms, however, the rate of decrease becomes much more rapid, the reduction being 5°.4, or above 2° per 100 fathoms; while, between 750 and 1,000 fathoms, it amounts to 3°.1, bringing down the temperature, at the latter depth, to an average of 38°.6. Beneath this there is still a slow progressive reduction with increase of depth, the temperature falling a little more than 2° between 1,000 and 2,435 fathoms; so that, at the last-named depth—the greatest at which it was ascertained—it was 36°.5. Thus it is obvious, either that the vast body of water occupying the deeper half of the Atlantic basin has been itself derived from a colder region, or that its temperature has been reduced by the diffusion through it of frigid water from a Polar source. The latter supposition best accords with the gradual depression of temperature exhibited between 500 and 1,000 fathoms, which corresponds with the "stratum of intermixture" of the cold area.

Notes. 7, S. (Con'd.)

The temperature soundings recently taken by Commander Chimmo, R. N., and Lieutenant Johnson, R. N., at various points in the North Atlantic basin, when the requisite corrections are applied for the influence of pressure on the bulbs of the unprotected thermometers employed by them, give results which are remarkably accordant with our own; so that it may be stated, with confidence, that the temperature of the deeper parts of the North Atlantic sea-bed is but a very few degrees above the freezing-point.

Now, a glance at the North Polar region, as laid down either on a globe or any projection of which the Pole is the center, shows that the Polar basin is so much shut in by the northern shores of the European, Asiatic, and American continents that its only communication with the North Atlantic basin—besides the circuitous passages leading into Hudson's and Baffin's Bays—is the space which intervenes between the eastern coast of Greenland and the northwestern portion of the Scandinavian peninsula. If, therefore, there be any such general interchange of Polar and Equatorial water as that for which we have argued, the Arctic current must flow through the deeper portions of this interspace, at the north of which lies Spitzbergen, while Iceland and the Faroes lie in the middle of its southern expanse. Now, in the channel that lies between Greenland and Iceland, the depth is such as to give a free passage to such a frigid stream; but, between Iceland and the Faroe Islands, there is no depth so great as 300 fathoms at any part, except in a narrow channel at the southeast corner of Iceland; so that an effectual barrier is thus interposed to any movement of frigid water at a depth exceeding this. A similar barrier is presented, not merely by the plateau on which the British Islands rest, but also by the bed of the North Sea, the shallowness of which must give to such a movement a not less effectual check than would be afforded by an actual coast-line uniting the Shetland Islands and Norway. Consequently it is obvious that a flow of ice-cold water, at a depth exceeding 300 fathoms from the surface, down the northeastern portion of this interspace, can only find its way southward through the deeper portion of the channel between the Faroe and Shetland Islands, which will turn it into a W. S. W. direction between the Faroe Islands and the north of Scotland, and finally discharge such part of it as has not been neutralized by the opposing stream coming up from the southwest, into the great North Atlantic basin, where it will

Notes.

7, 8. (Con'd.) meet the Iceland and Greenland currents, and unite with them in diffusing frigid waters through its deeper portion. In thus spreading itself, however, the frigid water will necessarily mingle with the mass of warmer water with which it meets, and will thus have its own temperature raised, while lowering the general temperature of that mass; and hence it is that we do not find the temperature of even the greatest depths of the Atlantic basin nearly so low as that of the comparatively shallow channel which feeds it with Arctic water.

It may be questioned, however, whether the whole body of Arctic water that finds its way through the channels just indicated could alone maintain so considerable a reduction in the temperature of the enormous mass which lies below 1,000 fathoms in the Atlantic basin, subject as this must be to continual elevation by the surface-action of the sun on its southern portion. And as the few reliable observations on deep-sea temperatures under the Equator indicate that even there a temperature not much above 32° prevails, it seems probable that that part of the cooling effect is due to the extension of a flow of frigid water from the Antarctic Pole, even north of the Tropic of Cancer. Of such an extension there is evidence in the temperature-soundings recently taken in H. M. S. Hydra, between Aden and Bombay, where the cooling influence could scarcely have been derived from any other source than the Antarctic area. (The lowest temperature actually observed in these soundings was 36½°. The temperature of 33½°, given previously, as existing below 1,800 fathoms, proves to have been only an estimate formed by Captain Shortland under the idea that the rate of reduction observed at smaller depths would continue uniform to the bottom, which the serial soundings of the Porcupine prove to be by no means the case.)

The unrestricted communication which exists between the Antartic area and the great Southern ocean basins would involve, if the doctrine of a general oceanic circulation be admitted, a much more considerable interchange of waters between the Antarctic and Equatorial areas than is possible in the Northern hemisphere. And of such a free interchange there seems adequate evidence, for it is well known to navigators that there is a perceptible "set" of warm surface-water in all the Southern oceans toward the Antarctic Pole; this "set" being so decided in one part of the Southern Indian Ocean as to be compared by Captain Maury to the Gulf Stream of the North Atlantic. (Physical Geography of the Sea, §§ 748–750.) Conversely, it would appear from the application of the necessary pressure-correction to the temperatures taken in Sir James Ross' Antarctic Expedition, the voyage of the Venus, &c., at depths greater than 1,000 fathoms, that the bottom-temperature of the deepest parts of the Southern oceanic basin really approaches the freezing-point, or is even below it. And if the temperature of the deeper portion of the North Pacific Ocean should be found to exhibit a depression at all corresponding to that of the North Atlantic, it must be attributed entirely to the extension of this Antarctic flow, since the depth of Behring's Strait, as well as its breadth, is so small as to permit no body of Arctic water to issue through that channel.

If further observations should substantiate the general diffusion of a temperature not much above the freezing-point over the deepest portions of the ocean-bed, even in intertropical regions, as a result of a general deep movement of Polar waters toward the Equator, forming the complement of the surface-movement of Equatorial water toward the Poles, it is obvious that such diffusion

Notes. 7, S. (Con'd.)

must exert a very important influence on the distribution of animal life; and, in particular, that we may expect to meet with forms which have hitherto been reputed essentially Arctic in the deep seas of even the intertropical region, and again in the shallower water of the Antarctic area. Such, there is strong reason to believe, will prove the case. In his recent annual address as President of the Royal Society, Sir Edward Sabine cites observations on this point made by Sir James Ross in his Antarctic Expedition, as confirmatory of the view entertained by that distinguished navigator, "that water of similar temperature to that of the Arctic and Antarctic Seas exists in the depths of the intermediate ocean, and may have formed a channel for the dissemination of species." The "similar temperature," believed by Sir James Ross to have had this general prevalence, seems to have been 39°, whereas the observations made in the Porcupine expedition distinctly prove that a temperature even below 30° may be conveyed by Polar streams far into the temperate zone, and that the general temperature of the deepest part of the North Atlantic sea-bed has more of a Polar character than he supposed.

Again, the deep-sea dredgings of the Porcupine expedition have shown that many species of mollusks and crustacea, previously supposed to be purely Arctic, range southward in deep water as far as those dredgings extended, namely, to the northern extremity of the Bay of Biscay; and it becomes a question of high interest whether an extension of the same mode of exploration would not bring them up from the abysses of even intertropical seas.

Now, as there must have been deep seas at all geological epochs, and as the physical forces which maintain the oceanic circulation must have been in operation throughout, though modified in their local action by the particular distribution of land and water at each period, it is obvious that the presence of Arctic types of animal life in any marine formation cannot be accepted as furnishing evidence *per se* of the general extension of glacial action into temperate or tropical regions. How far the doctrines now current on this point may need to be modified by the new facts now brought to bear on them, it will be for geologists to determine. The question may be left in their hands with full assurance of a candid reception of the fresh evidence now adduced.

The general results of the dredging operations carried on during the Porcupine expedition will now be concisely stated.

In the first place they show conclusively that there is no limit to the depth at which animal life may exist on the ocean-bed; and that the types found at even the greatest depths may not be less elevated in character than those inhabiting shallower waters. It would even be premature yet to affirm that the higher types occur in less abundance and variety than at more moderate depths; for it is by no means impossible that the use of the improved method of collection devised by Captain Calver, (which consists in the attachment of "hempen tangles" to the dredging-apparatus, by which the floor of the ocean is *swept* as well as *scraped*, and which often came up loaded when the dredge was empty,) which was employed with extraordinary success in the third cruise, may make as large an addition to our knowledge of the life of the sea-bottom explored by the dredge in the first and second cruises of the Porcupine, as it has done in the case of the cold area, where it revealed the astonishing richness of the bottom which the Lightning dredgings of the previous year had led us to regard as comparatively barren.

Secondly, they confirm our previous conclusion that temperature exerts a

Notes.

7, 8. (Con'd.) much greater influence than pressure on the distribution of animal life. Not only have we found the same forms presenting themselves through an enormous vertical range—no amount of fluid pressure being incompatible with their existence—but we have also, by a more complete survey of the relations of the warm and cold areas, established the very marked difference between the faunæ of two contiguous portions of the sea-bed lying at the same depth, which was indicated by the Lightning dredgings. It is remarkable, however, that this difference showed itself more in the crustaceans, echinoderms, sponges, and foraminifera, than it did in the mollusca, of which a considerable proportion were common to both areas. The abundance and variety of animal life on a bottom, of which the temperature is at least 2° F. below the freezing point of fresh water, is a fact which has all the interest of surprise; and it is scarcely less remarkable that the forms of mollusks, echinoderms, and sponges, which seem to be the characteristic inhabitants of the cold area, should attain a very considerable size. The precise limitation of the *Globigerina*-mud and of the vitreous sponges to the warm area, was a very striking manifestation of the influence of temperature, and has very important geological bearings.

Thirdly, they have largely added to the number of cases in which types that had been regarded as characteristic of earlier geological periods, and to have long since become extinct, prove to be still existing in the depths of the ocean; and greatly increase the probability that an extension of the like method of research to more distant localities would produce even more remarkable revelations of this character.

The doctrine propounded by Professor Wyville Thomson, in the report of the Lightning expedition, as to the absolute continuity of the cretaceous formation with the deposit of *Globigerina*-mud at present in progress on the North Atlantic sea-bed, has received such striking confirmation from the discovery of the persistence of numerous cretaceous types, not merely in our own explorations, but also in those carried on by the United States Coast Survey in the Gulf of Mexico, that it may be fairly affirmed that the *onus probandi* rests upon those who assert that the formation of true chalk has ever been interrupted since the cretaceous period. That period is usually considered to have terminated with the elevation of the cretaceous deposits of the European area into dry land. But according to the accepted doctrines of geology it is highly probable that, coincidently with the elevation of the European area, there was a gradual subsidence of what is now the Atlantic sea-bed; so that the *Globigerinæ* of the former area, with many accompanying types of animal life, would progressively spread themselves over the latter, as its conditions became favorable to their existence; and there seems no reason why they should not have maintained themselves in its deepest parts, through the comparatively small changes of level which took place in this portion of the earth's crust during the tertiary epoch.

Fourthly, the Porcupine explorations have enormously extended our knowledge of the British marine fauna, alike by the discovery of new types, and by the addition of types previously known only as inhabitants of other localities. The mollusca alone have as yet been fully examined; and Mr. J. Gwyn Jeffreys, whose authority upon this part of the subject is not second to that of any other naturalist, reports as follows: The total number of species of marine mollusca enumerated in his recently completed "British Conchology" (excluding the

Nudibranchs) is 451; and to these the Porcupine expedition has added no fewer than 117, or more than one-fourth. Of these as many as 56 are undescribed, while seven were supposed to be extinct as tertiary fossils. Sixteen genera, including five which are undescribed, are new to the British seas. "All that I can do," he says, "by continual dredgings in comparatively shallow water, during the last sixteen years, was to add about 80 species to the number described by Forbes and Hanley. I regard the present (although a large) addition as merely an earnest of future discoveries. In fact, the treasure of the deep is inexhaustible." The complete examination of the crustacea, which are in the hands of the Rev. A. M. Norman, and of the annelids, which have been undertaken by Mr. Claparède and Dr. Macintosh, will probably yield results scarcely less striking. It is, however, in the echinoderms and sponges, which are being examined by Professor Wyville Thomson, in the stony corals, which have been referred to Dr. P. M. Duncan, and in the *Foraminifera*, which constitute the speaker's own specialty, that the most interesting novelties present themselves. **Notes. 7, 8. (Con'd.)**

[9] Nature, December 9, 1869, p. 166. **9.**

[The following is from a discourse delivered by Dr. J. Gwyn Jeffreys before the Royal Institute: "The Deep-sea Dredging Expedition in H. M. S. Porcupine."]

* * * * * * * *

I will make a few remarks as to the mollusca obtained in the expedition, and with respect to that part of the sea-bed which I investigated:

1. *The Mollusca are mostly Arctic or Northern.*—This I have shown in my narrative as regards the western coasts of Ireland, which have hitherto been supposed to belong zoölogically to what Professor Edward Forbes called the "Lusitanian" province; and the present remark applies not only to deep water, but to shallow water, and even the bays. In Professor Wyville Thomson's cruise to the southwest of Ireland occurred two species which I was quite unprepared to see. These were *Solarium siculum*, and an unmistakable fragment of *Cassidaria tyrrhena.* The former inhabits the Mediterranean, Madeira, Canaries, and the coast of Portugal, and the latter has not been noticed north of Brittany. Such exceptions, as well as *Ostrea cochlear*, *Murex imbricatus*, and *Platydia anomioides*, it is difficult to account for; but, as all these species are said to inhabit deep water, the Equatorial current may have carried them northward, in an embryonic state; or it is possible that they may be likewise Northern species, and have not yet been discovered in high latitudes. We are nearly ignorant of the Arctic mollusca, owing to the difficulty of exploration; and those who assume that the marine fauna of the circumpolar seas is poor, or wants variety, ought to see the vast collection made by Professor Torell, at Spitzbergen. The greatest depth at which he dredged there was 280 fathoms. The soundings taken in 1868 by the last Swedish expedition reached 2,600 fathoms, when a *Cuma* and a fragment of an *Astarte* came up in the Bulldog machine. Soundings, however, are very insufficient for zoölogical purposes. Judging by the results of our own expedition this year, which have increased to such a wonderful extent our list of the British marine fauna living beyond the ordinary line of soundings, it may fairly be taken for granted that the arctic marine fauna is much less known than ours. I have not the slightest doubt that by another

Notes.
9.
(Con'd.) expedition to Spitzbergen, provided with improved machinery, and under the charge of the professor at Lund, or some other able zoölogist, the species obtained would be double the present number. It is evident that the majority, if not the whole of our submarine (as contradistinguished from littoral or phytophagous) mollusca originated in the North, whence they have in the course of time been transported southward by the great Arctic current. Many of them appear to have found their way into the Mediterranean, or to have left their remains in the tertiary and quaternary formations of the south of Italy. Some have even migrated into the Gulf of Mexico, as I will presently mention.

I cannot see much, if any, difference between the mollusca from the warm and cold areas of Dr. Carpenter. The number of species from the cold area, which also occurred in the warm area, is forty-four. Other species from the cold area, and not from the warm area, are eleven. Of these last, five are undescribed, and one is apparently sub-fossil, and may be a relic of the glacial epoch; so that there remain only five which are Arctic and North American, but which were not found in the warm area.

* * * * * * * *

3. *Relation to North American Mollusca.*—The late Dr. Gould, in his "Report on the Invertebrata of Massachusetts, (1841,)" gave 176 species of marine mollusca as inhabiting that coast. Mr. Mighels, Professor Stimpson, and others, have since described a few more species, making the total number about 200. I have found 60 of these as British, a dozen being from the present expedition. The size of the North American species is, so far as I have observed, smaller than that of our specimens of the same species, perhaps showing that their common origin was in the Arctic seas of Europe, and not of America.

* * * * * * * *

5. *Relation to the Mollusca of the Gulf of Mexico.*—I hope soon to have an opportunity of examining and comparing the mollusca dredged during the last three summers by Count Pourtales in the United States expeditions. The only species which I have yet seen from the Gulf of Florida are *Waldheimia Floridana* and *Terebratula Cubensis.* The former appears to be that variety of *Terebratula septata* (a Norwegian and now British species) which Professor Seguenza has described and figured under the name of *Waldheimia Peloritana*, from tertiary beds in Sicily; and the latter is closely allied to *Terebratula vitrea*, (Mediterranean,) and is perhaps a variety of that polymorphous species. Not only the external characters, but also the skeletons or internal processes of these American species correspond exactly with those of their European relatives. I must repeat that I am no believer in the doctrine or idea of species being "represented" in a geographical point of view. Species may be identical or allied, but not "representative."

6. *Gulf Stream.*—The northern character of the marine fauna, observed during the Porcupine expedition, is certainly at variance with the general notion that this "river in the ocean," or any branch of it, flows directly to our coasts; and I have elsewhere ("British Conchology," vol. 1, Intr., pp. xcviii and xcix; and Report of British Association, 1868, p. 236) endeavored to show that the occur-

Note. 9. (Con'd.)

rence in northern latitudes of tropical shells, seeds, and timber may be accounted for by the surface drift arising from the prevalence of westerly winds. But there is unquestionably a marine as well as an aërial circulation, Equatorial and Arctic currents as well as trade winds.

7. *Nature of the Sea bed.*—In that part of my report which contains a narrative of the expedition, so far as I was engaged in it, I have given some particulars which it is unnecessary to recapitulate. Some of the pebbles and gravel from my deepest dredgings (1,215 to 1,476 fathoms) have been examined by Mr. David Forbes, the eminent mineralogist, and he has kindly furnished me with the detailed report which I append to this communication. Among the pebbles and gravel were several fragments of true volcanic lava, which throw a considerable light on the course of the Arctic current along the western coasts of Ireland. He is of opinion that these volcanic minerals came from Iceland or Jan-Mayen. Mr. Forbes has also, at my request, carefully and completely analyzed a portion of the Atlantic mud from 1,443 fathoms, the pebbles and gravel having been previously removed from it by sifting; and the result shows that its chemical composition differs greatly from that of ordinary chalk. The sifted mud contains, out of 100 parts, 50.12 only of carbonate of lime, and no less than 26.77 of fine insoluble gritty sand or rock débris; while chalk consists almost entirely of carbonate of lime, and seldom contains more than from 2 to 4 per cent. of clay, silica, and other foreign material. But I do not say that this single analysis is conclusive. I may observe that stony ground did not occur, during the present expedition, beyond about 550 fathoms, the sea bed, at greater depths, being covered by mud, or what is technically called "ooze." This superstratum appears to consist chiefly of decomposed animal matter, mixed with the shells of pteropods and *Globigerinæ*, which must have dropped from the surface of the sea. I have myself seen living *Globigerinæ* in great abundance taken with *Spiriales* in the towing net; and Major Owen's papers in the Journal of the Linnæan Society for 1865 and 1866 leave no doubt, not only that *Globigerinæ*, and other free *Foraminifera*, live on the surface of the mid-ocean, but that they have the power, by protruding their pseudopodia, of descending a few inches and rising again to the surface. Sessile or fixed *Foraminifera*, of course, cannot do this; but I have found some of these living on the surface and attached to floating sea-weed *(Fucus serratus)* at a considerable distance from land. The fresh appearance of the sarcode in *Foraminifera* taken from great depths does not of itself prove that they live there, when we consider the comparatively antiseptic or preservative property of sea water, as well as the extremely minute size of the aperture in each cell which contains the sarcode. Some *Foraminifera*, however, inhabit only the bottom of the sea.

* * * * * * * *

9. *Oceanic Currents.*—The Arctic or northern current probably runs with greater rapidity and force in some places than in others where the flow seems to be very slow and feeble. Everywhere (as I pointed out in my Shetland report for 1863) the motion must be extremely gentle or imperceptible at the bottom in

Notes.

9. (Con'd.) deep water, as we find the most fragile and delicate corralines from stony ground quite uninjured.

* * * * * * * *

At the meeting of the Royal Society at which the observations described in the above paper were communicated, Professor Alexander Agassiz gave an account of the principal results arrived at by the American Dredging Expedition. The ground explored was limited to a length of about 120 miles by 60 to 90 miles in width, between the Florida Keys and the northern coast of Cuba; and although the depth reached was by no means as great as that attained by the last British expedition, not being much more than one-third of it—about 820 fathoms—yet the results were fully as striking, and agree in the main points with the conclusions arrived at by the British explorers.

Commencing with the sponges, which contained a great number of siliceous forms, he gave, as the results of the examination of Dr. Oscar Schmidt, of Graatz, the specific identity of the majority of the species with Mediterranean, Azoric, and Atlantic species, showing a geographical range quite unprecedented, and *extending the Atlantic fauna from the Gulf of Mexico to the Bermudas, the Azores, the Mediterranean, the western coasts of Europe, and extending far north to the boreal regions of Norway, Iceland, and Greenland.* These same results would apply, as far as the collections have been examined, to the *Echinoderms*, *Mollusca*, and *Crustacea*, though the number of identical species in these branches over this extensive Atlantic area is much smaller. Among the *Echinoderms*, the *Echini* specially showed several new and interesting forms, recalling types characteristic of the cretaceous period; one genus especially, the genus *Salenia*, is represented in our (the British) seas by a most interesting species. Another cretaceous type, a new genus of *Spatangida, (Pourtalesia,)* was found in deep water in Florida, and, like the *Crinoid* genus, *Rhizocrinus*, was also dredged by the Porcupine expedition. Several other species of *Echinoderms* were also shown to be identical on both sides of the Atlantic.

Professor A. Agassiz gave, besides, an instance of one of these so-called cretaceous generic types, which was only the young stage of a well-known genus represented from the time of the chalk through the tertiaries, and which is now found living in the tropical seas; showing how careful we ought to be in our generalizations, when drawn from a class where the transformations from the young stages to the adult are as great as they are in *Echinoderms.* He gave as an example of this the case of two species of *Echini*, one of which is known under one generic name, *(Stolonoclypeus,)* as the adult, in Florida, while the young is known under a different generic name *(Echinocyamus)* in Europe, and endeavored to explain by the action of the currents the migration of the pelagic embryos, many of which remain in a helpless condition for several months, and thus to show how changes of currents, brought about by the elevation or subsidence of portions of continents, would fully account for the present limitation of marine faunæ.

10. [10] Oestreichische Zeitschrift für Meteorologie, V. No. 4, February 15, 1870, p. 94.

Notes. 11-19.

[11] Athenæum, August 21, 1869, p. 248.

[The following is from the President's address at the inaugural meeting of the British Association, at Exeter, August 18, 1869:—Hydrographic Office.]

I am informed by Dr. Carpenter that dredging has been successfully carried down to more than 2,400 fathoms, (nearly the height of Mont Blanc,) and that animal life has been found even at that depth in considerable variety, though its amount and kind are obviously influenced by the reduction of temperature to Arctic coldness. A very careful series of temperature soundings has been taken, showing, on the same spot, a continuous descent of temperature with the depth, at first more rapid, afterwards pretty uniform. * * * * All the observations hitherto made go to confirm the idea of a general interchange of polar and equatorial waters, the former occupying the lowest depths, the latter forming a superficial stratum of 700 or 800 fathoms. The analyses of the water brought up indicate a large proportion of carbonic acid in the gases of the deep waters and a general diffusion of organic matter.

[12] Journal of the American Geographical and Statistical Society, vol. ii, part 2, pp. cvi, *et seq.* These perorations of Mr. Blunt appear much like an echo, but a much deteriorated one, of Mr. Findlay. 12.

[13] "I was truly pleased at reading the other day (I know not whether it was accurate) that the Gulf Stream had proved to be a delusion. The Gulf Stream was almost as great a nuisance as Macaulay's New Zealander, or the German who evolves things from the depths of his consciousness. One could not mention the weather without giving a chance to somebody to clothe himself with the true scientific swagger and hurl the Gulf Stream at your head. There are certain remarks which nobody ever makes without a certain air of superior wisdom, and the man who affected familiarity with the Gulf Stream always seemed to feel himself six inches taller in consequence. I should have real pleasure in learning that the Gulf Stream had been definitely exploded." (Cornhill Magazine, July, 1869, p. 50.) 13.

[14] Weser Gazette, February 16, 1870. 14.

[15] Kohl, Geschichte des Golfstromes, (History of the Gulf Stream,) Bremen, 1868, p. 173, citing the Journal of the Royal Geographical Society, vol. 26, p. 26. Findlay, however, does not speak of the Gulf Stream, but of the "warm waters of the equatorial regions passed northeastward from the Gulf Stream," meaning, doubtless, a drift and not the Gulf Stream. 15.

[16] Diagram of the Gulf Stream, to illustrate the paper by A. G. Findlay. Proceedings Royal Geographical Society, XIII, p. 103, (see note 6.) 16.

[17] Kohl, Geschichte des Golfstromes, (History of the Gulf Stream,) p. 222. 17.

[18] Geographische Mittheilungen, 1865, table 5. 18.

[19] Wind and Current Charts of the North Atlantic, by Lieutenant Matthew F. Maury, United States Naval Observatory, 1852; thermal sheets, Nos. 1 to 8, series D. These eight sheets extend from the Equator to latitude 65½° N., and from longitude 100° W. to longitude 20° E. of Greenwich. 19.

Notes.

20-24. [20] Schmid, Lehrbuch der Meteorologie, p. 254.

21. [21] Onderzoekingen met den Zeethermometer, als Uitkomsten van Wetenschap en Ervaaring, angaande de Winden en Zeestroomingen in sommige gedeelten van den Oceaan. Uitgegeven door het Koninglijk Nederlandsch Meteorologisch Instituut te Utrecht, in 1861, quarto.

22. [22] Report to the Committee of the Meteorological Office on the Meteorology of the Atlantic, between the parallels of 40° and 50° N., as illustrated by eight diagrams of observations taken on board the mail steamers running to and from America, with remarks on the difference in the winds and weather experienced, according as the ship's course is westerly or easterly, and on the probable causes of the difference. By Captain Henry Toynbee, Marine Superintendent, Meteorological Office. London, 1869.

23, 24. [23 and 24] Proceedings of the Royal Geographical Society, XIII, pp. 229 *et seq*, and Geographische Mittheilungen, 1869, p. 436.

[The following paper, read before the Royal Geographical Society, contains the data referred to:]

On the Surface Temperature of the North Atlantic, in reference to Ocean Currents. By Nicholas Whitley, C. E.

The thermometrical observations on which this paper is founded were commenced on the Cornish coast in 1849, and were afterward extended to the Scilly Isles, the Seven Stones Light-ship, to Yarmouth, and to the Shetland Isles. And, further, in order to ascertain the temperature of the surface water across the Atlantic, extracts were made from the log-books of Cunard's steamships sailing between Liverpool and New York, for a period of five years; which have been reduced to monthly means at every five degrees of longitude, and are embodied in the table appended to this paper.

The primary object was an endeavor to determine the influence of the Gulf Stream on the climate and agriculture of the British Isles.

In this paper I purpose only to state the general results obtained, and to apply the evidence as a test of the existence of ocean currents.

The chart exhibited to the meeting shows the surface temperature of the sea taken in five voyages in different years, and similar observations are given in the table at the end of this paper.

In January the sea around the Scilly Isles is somewhat warmer than on the western coast of Ireland, and there is a decreasing temperature from 51° at the Seven Stones to 42° at Shetland, being a difference of only 9° in 700 miles of latitudinal distance. The January temperature of the water continues also to decrease down the eastern coasts of Scotland and England, until it reaches its minimum of 37° at Great Yarmouth.

We may, therefore, infer that the North Sea in winter derives its warmth rather from the strong tides which pass around the north of Scotland than from any warmer water flowing through the Straits of Dover.

The mean temperature of the sea in Penzance Bay, last January, was 50°, and between Hull and Hamburg, 43°. In the same month, on the American coast, the sea is very cold, seldom rising above the freezing point, and often from two to four degrees below it. The chilling effect of the Arctic Current is felt far down the coast; but where the water is somewhat sheltered from its influence by the land of Nova Scotia and Newfoundland it rises several degrees in warmth. Notes. 23, 24. (Con'd.)

The extent and greatest intensity of the Arctic Current is sharply shown by the thermometer in every voyage. The cold water on the Banks of Newfoundland reaches its mean monthly minimum of 30° in January, and its mean maximum of 52° in September, and its width is fully 400 British miles.

On the eastern side of the cold current, and in close proximity to it, there is a bed of very warm water having a mean temperature in January of 57°, being 27° warmer than that on the Banks, over a width of about 200 miles. This appears to be a strong eddy of the Gulf Stream, curving northward, and holding the Arctic Current in its warm embrace.

From this part of the sea to near the Irish coast the warmth is more equally distributed through the water, and the thermometer does not detect any well-defined branch of the Gulf Stream flowing to the N. E. There is, however, a decided rise in the temperature about the middle of the Atlantic, amounting to from four to six degrees above that of the sea at Scilly, and the figures on the chart appear to indicate that it lies in a S. W. and N. E. direction. It is most probably the drift of the Gulf Stream driven to the N. E. by the prevailing S. W. wind.

The observations at the coast stations on the west of Ireland show a temperature of 3° below that of the open sea 350 miles to the west.

Our S. W. wind has its birthplace where the temperature of the sea is at least 55° in January, causing the thermometer on the Cornish coast, under its influence, to stand steadily at 52°, and the great warmth of the past winter resulted from the continued persistency of this wind rather than from any excess of heat in the sea.

The S. W. wind gives to Penzance a mean winter temperature of 44°, being the same as that of Montpelier; Cork falls short of it by only half a degree; and the Scilly Isles at this season exceed this noted winter resort by 2½°.

Table showing the temperature of the surface water of the Atlantic Ocean, at every 5° of longitude, from the south of Ireland to the Banks of Newfoundland, on the course of Cunard's steamships.

Months.	On the Banks.	Longitude.						
		40°	35°	30°	25°	20°	15°	10°
January	30	57	53	54	55	54	52	51
February	31	54	53	52	53	52	52	50
March	32	54	54	55	54	54	52	51
April	34	57	55	55	52	54	53	52
May	34	55	54	55	56	55	53	53
June	40	60	59	58	56	58	58	57
July	45	60	59	58	59	60	58	59
August	50	61	59	60	59	60	60	59
September	52	59	59	60	59	60	59	58
October	47	59	59	56	56	57	57	55
November	44	58	57	58	59	57	54	53
December	32	55	54	54	54	54	53	52
Mean of the year	39.2	57.2	56.2	56.2	56.0	56.2	55.1	54.2

Notes.

23, 24. (Con'd.) The means represented in the preceding table show that east of the cold water of the Newfoundland Banks, (the Polar Stream, which has there a width of 400 miles, and a temperature in January of 30°, and in September of 52°,) there is a bed of warm water, 200 miles in width, with a temperature of 57° in January and 61° in August. Between this bed and the Irish coast the temperature is more uniform; there is, however, in the middle of this distance, in about longitude 25° W. of Greenwich, a belt of water of a decidedly higher temperature.

25. [25] Journal of the Scottish Meteorological Society, new series, No. VIII. Edinburgh and London. October, 1865, pp. 256.

On the Temperature of the Sea on the Coast of Scotland.—By Alexander Buchan, Meteorological Secretary.

To ascertain the temperature of the sea on the coast of Scotland, and particularly the annual and diurnal changes to which it is subject, observations have been made at different points round the coast, beginning with January, 1857, to the present time. These have been regularly published in the society's quarterly proceedings. From these observations the following tables have been constructed. Since the times of observation were not the same at the several stations, we shall state the years and the number of times they were made monthly at the different places. All the observations were made at a depth of 6 feet, except some of the Harris observations, afterward to be referred to.

At Sandwick, Orkney, the observations were begun in January, 1857, and have been continued regularly to the present time, generally from five to seven times a month.

At Stornoway, the observations began in February, 1857, and have been continued, with one or two blanks, to the present time. During the first four years the temperature was taken four to nineteen times each month; during the next two years, generally three times; and during the last two years, only once a month.

At Harris, the observations were made on an extensive scale, under the superintendence of Captain Thomas, H. M. C. Woodlark, assisted by Mr. Sharbau, while surveying the Outer Hebrides. During the winter months the temperatures were observed in East Loch, Tarbert, Harris; and, in summer, among those islands where the survey was in progress, but always within a radius of 18 miles. The temperatures, at the depth of 6 feet, were observed at 9 a. m. and 3 p. m., from 1st November, 1858, to 30th November, 1863; at 9 p. m. from 1st May, 1859, to 30th November, 1863, (except December, 1859, and January, February, March, 1860;) and the daily minimum temperature from January, 1859, to November, 1863. The above have all been brought, in Table II, to the mean of the five years beginning November, 1858, and ending November, 1863. The temperatures, at depth of 1 foot and 24 feet, were observed from June to October, 1858; and the temperature, at 6 feet as compared with 60 feet, from June to September, 1859. In addition to these, term-day observations were made on the 21st or 22d of each month, beginning with May, 1859, and ending with November, 1863. They were made sixteen times each day, beginning at 6 a. m., then every second hour, and at 9 a. m., 3 p. m., 9 p. m., and 3 a. m. The results of this laborious and most valuable series of observations are given in Tables II and III. **Note. 25.** (Con'd.)

At Oban, the observations were generally made from four to seven times a month, extending from May, 1859, to March, 1865, with the exception of six months, from November, 1859, to April, 1860.

In the sea west of Oban, (including the sea off Coll, Tyree, Mull, &c.,) the observations were made under the direction of Captain Bedford, R. N., and by him transmitted to the society's office, and published annually in the proceedings of the society.

At Otter House, (east of Lochgilphead,) the observations began in October, 1858, and have been continued to the present time. In 1858, 1859, and 1860, they were taken daily; but since then three times a month, viz, on the 10th, 20th, and 30th.

At Westhaven, near Carnoustie, the observations were taken by Mr. Proctor, the society's observer at Barry, from January, 1857, to the present time, once, twice, or more rarely thrice a month.

At North Berwick, the observations were taken by the society's observer at Smeaton, from April, 1857, to June, 1861, thrice a month, generally on the 5th, 15th, and 25th.

At Dunbar, the observations were made by Mr. Storie, the society's observer at East Linton, from January, 1857; to December, 1864; during the first five years, generally on the 5th, 15th, and 25th of the month; and during the last three years, generally on the 15th only.

Captain Thomas has made daily observations of the temperature of the sea since 2d March, 1864, at Trinity Chain Pier, near Edinburgh, at a point 225 yards from high-water line, and about 40 yards at low water; the depth being 6 feet at low-water spring tide, and 25 feet at high-water spring tide. He has also made term-day observations, similar to those made by him at Harris, on the 21st of the month, beginning with September, 1864.

Observations of the temperature of the sea have also been made at Bernera, in Lewis, and East Yell, in Shetland, but the blanks which occur are too numerous to admit of a satisfactory mean being taken; at Easdale, in Argill, but the thermometer used had unfortunately been a very defective instrument; at Bressay, Portree, Tobermorey, the Moile, Dunrobin, and Portsoy, but in no case for a period exceeding a year.

In the results which have been published by the society it has all along been assumed that the mean temperature of the sea for any month at any point has been the simple arithmetic mean of all the observations which were made there during that month; and from these means alone Table IV has been constructed, in the way adopted and described in previous papers. This table gives the mean temperature of the sea thus obtained during the months of the year at nine places on the coast of Scotland. The time (about eight years) is sufficiently long for a pretty close approximation to the mean temperature; and the table possesses further value, seeing it contains only the results of observations.

But many interesting questions arise out of a comparison of the results obtained at different stations; and it is evident that no nice comparisons could be satisfactorily made, or reliable conclusions drawn, unless with observations

Note.
25. carried on at the different places over the same years, and made on the same
(Con'd.) days of the month. For a single observation made in a month, though valuable as an observation, cannot, in most cases, be accepted as the mean temperature of the sea for that month. Thus, at Harris, in October, 1862, the temperature was 54° on the 12th and 44°.6 on the 21st, the mean temperature of the month being 50°.8. Daily observations, during the whole time, were made only at Harris and west of Oban stations, the vessels employed on the survey affording facility for such observations. But when, as happened in some cases, the observer resided some miles from the place of observation, the number of observations were necessarily limited.

Since observations were made four times a day at Harris, from 1st November, 1858, to 30th November, 1863, this place and period of time have been fixed upon as the standard to which the observations at the other places have been brought. The method by which Table V, giving the results, was constructed, will be best explained by the following example: At Sandwick, during November, 1858, the temperature of the sea was taken on the 1st, 8th, 13th, 19th, and 28th of the month, giving 49°.6 as the mean temperature of the month. The temperatures at Harris on the same days were extracted from the schedule; these observations gave the mean temperature at Harris to be 49°.0. This operation was performed for each of the other sixty months of the period, and thus monthly means were obtained for Harris, strictly comparable with the means deduced from the Sandwick observations, both series being made exactly on the same days throughout. These monthly means for Harris and Sandwick are given in Table I, to which is added the monthly difference for Sandwick. The monthly temperatures of Sandwick, given in Table V, were then obtained by applying to the Harris temperatures the above monthly differences. The means for the other stations were calculated in the same way as those for Sandwick. Table V, therefore, gives what would have been the mean temperatures, if daily observations had been made at each of the nine stations, from 1st November, 1858, to 30th November, 1863.

Daily Range of the Temperature of the Sea at Harris.—Table II.

Observations to determine the daily range or horary variation of the temperature of the sea were made at Harris only. The temperatures were observed on fifty-two months, on the 21st or 22d of the month. The fluctuations of the temperature of the sea are chiefly determined by the changes of the temperature of the air. The only disturbing influence arises from currents of the sea, and occurs seldom; and when it does occur the effect is very slight. Hence the fluctuation varies considerably from day to day, both as regards the amount and the times of occurrence of the daily maximum and minimum temperature. The amount is greatest when the weather changes on, or immediately preceding the day of observation, and least when the temperature of the air has varied little for some time. The greatest amount that was observed occurred on the 21st October, 1862, when the temperature was 44°.5 at noon, and 50°.1 at 6 a. m. the following morning, having thus varied 5°.6 in eighteen hours; and on the 21st November, 1859, when it was 45°.3 at 10 a. m., and 50°.6 at 6 a. m. of the following morning, having thus risen 5°.3 in twenty hours. But the range on any particular day is rarely so much as 3°.0. On twenty-nine out of the fifty-two days it was less than 1°; on twelve days it was between 1° and 2°; on seven days between 2° and 3°; and on four days only above 3°. On six of the days it varied only two-tenths of a degree. **Note. 25. (Con d.)**

The mean daily range for the months and the year is a point of considerable interest, since it supplies the correction, if any, to be applied to series of observations made at different hours of the day, to reduce them to the mean temperature of the day. It is evident that, as the number of observations is increased of which the mean is taken, the mean of any month thus determined will continue to fall more and more below such high means as 2°, or even 1°, until a sufficient number of observations have been obtained to give the true mean daily range. Since none of the means of the months in Table II include more than five years, the means of most of the months must be expected to be too great. Thus November, 1°.3; July, 1°.1; January, April, and May, 0°.9, are all doubtless too great. If, however, we combine the months into the seasons, the number of observations for determining the true means is largely increased, and thus the mean daily range of winter becomes 0°.4, and of the other seasons 0°.6. Again, by combining the seasons into the year, and taking the means of the different hours, the mean daily range of the temperature of the sea for the year, as a whole, is found to be only 0°.32 by the term-day observations.

The mean daily range has been determined in a different way. The daily maximum of the sea is reached about 3 p. m., and the minimum was observed directly, both of which means, deduced from 2,080 daily observations, are given in Table III. The difference gives the approximate mean daily range, which is valuable as giving more exactly the mean daily range of the different months. If these figures be laid down in a curve, it will be seen that there are two maxima and two minima periods in the year. The longest maximum occurs from April to August, culminating in June, 0°.72; and the shortest in December and January, culminating in December, 0°.82. The first minimum period is in February and March, 0°.38; and the second in September, October, and November, 0°.36. Hence the greatest daily variation of the temperature of the sea takes place when the sun's rays are exerting their greatest heating power, and again when the winter cold has begun to set in with greatest severity. The least variation occurs when the sun has begun to decline, and frosts are slight and of rare occurrence; and again when the sea has been cooled to its lowest point, and the sun has scarcely yet begun to raise its temperature.

These two modes, by which the mean daily range for the year has been calculated, must not be confounded together. For in determining the mean daily range from the term-day observations, the mean temperature of each hour is first ascertained, and the difference of the warmest and coldest hour is considered as the range. But when the range is determined from the minimum temperatures, the lowest temperature of each day is taken, at whatever hour or instant it may occur. In this case every daily minimum is found, and tells on the final result. Not so, however, in the case of the term-day observations; for with regard to these the minimum of any day is found only when it happens at the hour of observation, and when it is observed, tells on the final result only when it takes place at the mean time of its occurrence. Hence, while the mean daily range deduced from the minimum temperatures is 0°.57, it is only 0°.32 from the term-day observations. For the same reason the mean daily range of the air, Note. 25. (Con'd.) 5°.8, would have been about a degree more if it had been deduced from maximum and minimum observations.

It follows, then, that the mean temperature of the sea, on a series of years, as observed with a common thermometer, cannot to any appreciable extent be modified by the hour at which the observations are made; and consequently all the observations of the different stations, though made at different hours, may be considered to be quite comparable to each other.

From the means of the year in Table II, we observe that the sea reaches its maximum daily temperature about four in the afternoon, and falls to its minimum temperature about half-past five in the morning. The maximum occurs a little earlier during the winter months, and a little later during the summer months. The minimum occurs about 8 a. m. during the winter, and about 3.30 a. m. during summer; or, generally speaking, near sunrise. Since the maximum occurs at 4 p. m., and the minimum at 5.30 a. m., it follows that the sea parts with the heat it receives from the sun more slowly than it acquires it.

Daily Range of the Temperature of the Sea and Air Compared.—Table II.

The range of the temperature of the air is always greater—generally very much greater—than that of the sea. Thus, while the greatest range observed in the sea on any of the days was 5°.6, a range of 21° was observed in the temperature of the air on the 21st May, 1862. On that day the temperature was 60°.8 at 6 p. m., and at 3 a. m. it had fallen to 39°.8, having thus fallen 21° in nine hours. A daily range of from 12° to 20° in the temperature of the air which is resting on the sea is not an unusual occurrence; and the air in inland situations is subject to much greater fluctuation.

Again, the mean daily range of the air during the seasons, each of which is deduced from about twelve days' observations, is as follows, beginning with winter: 1°.6, 7°.9, 7°.5, and 3°.1; while the mean change of temperature of the sea is only about half a degree. The mean daily range, during the year, is 5°.8; and as it has been deduced from fifty-two days' observations, recurring regularly every month, 5°.8 may be assumed as the mean daily range; and the corrections given in Table II as the corrections to be applied to observations made regularly with common thermometers, in the west, at any particular hour, so as to deduce from the mean of these observations the mean temperature of the year. These corrections will be smaller during the winter months, and larger during the summer months; but the amount of the correction for each month cannot be determined from this Table, because the number of observations are too few, considering that the changes of temperature are so irregular in their occurrence.

From these observations it appears that the mean temperature of the air occurs a little before nine in the morning and a little before eight in the evening. The maximum temperature occurs about 3 p. m., and the minimum about 3 a. m. Since the maximum and minimum temperatures of the sea occur respectively at 4 p. m. and 5.30 a. m., it follows that the extreme temperatures of the sea occur from one hour to two and one-half hours later than those of the air. The temperature of the sea reaches its annual maximum temperature about the middle of August, and its minimum temperature in the last week of February; and about the 21st of May and the 10th of November the temperature is about the mean of the year, or 48°.9. The mean temperature of the air occurs

Note. 25. (Con'd.)

about the beginning of May and middle of October; the maximum in the third week of July, and the minimum about the beginning or middle of January. Hence these periods occur from three to four weeks later in the ocean than in the air. The mean temperature of the sea is about a degree above the mean temperature of the air, as determined by these sixteen observations a day during fifty-two months.

In comparing the mean monthly temperatures in Table II with those in Table III, it must be kept in view that Table II gives the mean temperature of the 21st of the month, and Table III of the 15th, or middle of the month. Hence, in those months during which the temperature is increasing, the means of Table II exceed those of Table III, and in the other months fall short of them.

Monthly Temperature of the Sea at Harris.—Table III.

The highest mean temperature of any month, 57°.4, occurred in August, 1859, and the lowest, 41°.2, in February, 1860, showing a difference of 16°.2. The three warmest months in order are, beginning with the warmest, August, July, and September; and the three coldest, February, March, and January. The months during which the greatest change of temperature occurs are October, November, December, and January, when the temperature makes the great annual fall; and April, May, and June, when it makes the great annual rise. These months also exhibit the greatest fluctuations and variations of temperature, the increase or decrease being then frequently delayed or interrupted. The greatest difference in the mean temperature of any month, from year to year, occurs in July; in 1859 it was 56°.8, and in 1862 it was 52°.0, showing thus a difference of 4°.8. A comparison of September with June will show the interesting fact that, as regards the temperature of the sea in the west, September is, in every way, to be preferred to June, its mean temperature and its lowest mean having been 2° warmer.

The mean annual temperature of the sea, at Harris, was 49°.6 in 1859; 47°.5 in 1860; 49°.1 in 1861; 48°.8 in 1862; and 49°.2 in 1863, showing thus a difference of 2°.1 in the annual variation. The mean temperature of the air, in the west, in these same years, was 48°.1, 45°.7, 48°.1, 47°.4, and 47°.9, showing an annual variation of 2°.4. Again, at Harris, in 1860, the temperature of the air in March, April, and May, was 41°.4, 45°.2, and 51°.0; while, in the same months, that of the sea was 42°.3, 43°.3, and 45°.7, showing a rise of 9°.6 in the temperature of the air, but only 3°.4 in that of the sea. If compared during successive days, the differences would be much more striking. Hence, though the differences of the temperature of successive days be much less in the case of the sea than of the air, and even of successive months considerably less, yet the differences of the mean temperatures of the sea and air of successive years closely approximate to each other. This shows that, though the sea soon begins to be influenced by a change in the temperature of the air, *a long time must elapse before the change be completely effected.*

Temperature of the Sea at different Depths.—Table III.

There are two sets of observations to illustrate this point, the one giving a comparison 1 foot with 24 feet, and the other 6 feet with 60 feet. Both observations were made during the summer months. As regards extreme tempera-

Note.
25. tures at these depths, it will be seen that, during the time the temperature was (Con'd.) increasing, the temperature at 1 foot was about 1° above that at 24 feet deep; but the temperature at 6 feet was 2° above that at 60 feet deep. The mean differences were about half the above.

When the temperature was falling, in September and October, the mean temperature, at a depth of 24 feet, was 1° *warmer* than at 1 foot, and about 0°.8 *warmer* at 60 feet than at 6 feet. This is instructive, and shows the value of observation over theoretical deductions; for theory might have led to the supposition that the warmer water would have floated on the top of the colder. The explanation is, that at this time the water of the sea is not in a state of equilibrium; that a disturbing agent is at work, (the cooling of the surface-water,) causing a continual descent of the colder and therefore heavier particles, and an ascent of the warmer and lighter particles to supply their place—a process which goes on as long as the surface is colder than any of the underlying watery strata. The difference between the temperature of the surface and that of several fathoms below the surface, shows forcibly the long time required in effecting a complete correspondence between the temperature of the sea and that of the air; for being brought about by upward and downward currents, the difference of whose temperatures is very small, the motion of the currents and the interchange of temperature resulting therefrom must proceed at a very slow rate.

Extreme Temperatures observed at different Places.—Table IV.

The highest temperature observed, up to 31st August, 1865, was 61°.5, at Otter House, in July, 1859; and the lowest 33°.7, at Trinity Chain Pier, in February, 1865, the difference being 27°.8. The temperature of 63°.0 was recorded at Westhaven, in September, 1858. A comparison of the mean temperature of the sea at Westhaven with the mean temperature at the other stations, during April, May, June, and July, (Tables IV and V,) shows an excess of about 3° at Westhaven. The temperature is very carefully taken by Mr. Proctor, each observation being verified by repetition three times. At full tide the temperature is taken 22 yards from the coast line, and at ebb tide 500 yards, always where the undisturbed body of sea-water is either gently ebbing or flowing, or rolling in on the shore in huge broken waves. The tide advances and recedes over sandstone rocks, inclined seaward at an angle of 30°, thickly strewn with transported boulders of every variety of size and mineral character, and covered with a rich marine flora. This tidal slope is always wet, even at low water. Immediately to the west, opposite to Carnoustie, the tidal slope is fine, yellow sand, sloping at an angle of 15°, which, being quite dry at ebb tide, becomes greatly heated by solar radiation, and cooled by radiation during the night. Is the anomalously high temperature at Westhaven due to some local sea current setting in from the heated sands at Carnoustie? This supposition is rendered more probable by the consideration that the excess of temperature takes place during those months when the direct heating power of the sun's rays most exceeds the temperature of the sea. These observations do not, therefore, give the temperature of the North Sea during the summer months, but they are valuable as having an important bearing on the local climate of the district. On the east and west the highest temperature at each station is about 60°; but in the north, at Stornoway and Sandwick, where the strength of the sun's rays is less, it is 2° or 3° less. But the greatest differences exist between the lowest temperatures of the west and the east. In the west the lowest temperature observed was 39°.1, at Harris, in January, 1862; while in the east, at Trinity Chain Pier, the temperature of the sea fell to 33°.7 in February, 1865. Note. 25. (Con'd.)

Distribution of Sea Temperature round Scotland.—Table V.

Annual Temperature.—The observations in the west are from five places, beginning with Otter House in the south, in latitude 55° 58′ N., to Sandwick in the north, in latitude 58° 2′ N. They thus extend over two degrees of latitude. Does latitude appear to affect the annual temperature? The annual temperatures, in the order of their latitudes, are as follows: Otter House, 49.02; Oban, 48.72; Harris, 48.89; Stornoway, 49.05; and Sandwick, 48.85. The difference of these numbers is so slight that we may conclude that the annual temperature of the sea along the coast of Scotland is practically uniform, from the Clyde to the Orkney Islands. Observations were made daily at Bressay Light-house, Shetland, for one year, beginning with April, 1857, and ending with March, 1858. The result gives the annual mean of Sandwick, 49°.9; and of Bressay, 49°.4. Thus, for this year, Bressay sea-temperature was half a degree less than that of Sandwick. It is, however, probable that, if the observations had been continued for a number of years, the difference between the two places would have been less than half a degree. It is very desirable that observations of sea-temperature were made in the southwest of Scotland, off the coast of Wigtownshire, and in the north of Shetland, in order to ascertain if any material difference exists in the temperature of the sea at these two extreme points.

There is, however, a great difference in temperature between the Atlantic and the North Sea. Leaving out Westhaven, for reasons already given, the annual temperature of the sea at Dunbar and North Berwick is 47°.8, or 1°.1 less than that of the Atlantic. The same fact is shown by the daily observations made by Captain Thomas at Trinity Chain Pier, which began in March, 1864. In the following Table they are compared with Otter House and Sandwick:

Mean temperature of the sea at Trinity Chain Pier, Otter House, and Sandwick, from 1st March, 1864, to 31st August, 1865.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
Trinity Chain Pier	39.4	36.4	38.7	43.8	49.0	53.7	56.0	56.2	53.6	49.6	44.9	43.8	47.1
Otter House	43.8	42.2	42.8	45.2	46.5	50.4	55.3	54.8	53.6	52.0	49.8	46.4	48.6
Sandwick	44.1	42.6	42.2	43.4	44.9	49.7	52.5	54.2	54.0	51.6	49.0	49.1	48.1

These mean temperatures, at Trinity Chain Pier 47°.1, at Otter House 48°.6, and at Sandwick 48°.1, fully bear out the conclusion already arrived at, that the temperature of the Atlantic is fully a degree above that of the North Sea.

Comparison of the Mean Temperature of the Sea with that of Air round the Coast of Scotland.

The mean annual temperature of the air on the east coast of Scotland, south of the Moray Firth, is 47°.1; and on the west coast, south of Skye, 48°.0; in

Note.

25. (Con'd.) the Pentland Firth it is 46°.6; at Stornoway, in Lewis, 46°.1; at Sandwick, in Orkney, 45°.9; and at Bressay, in Shetland, 45°.4. The sea, therefore, is everywhere warmer than the air. In the east, 0°.7; in the west, 0°.9; in Lewis, 2°.9; and in Orkney, 3°.0. Thus the temperature of the west is above that of the east, both sea and air being about a degree higher. Part of the excess of the temperature of the sea is probably due to the fact that all the low temperatures of the air are fully registered by the thermometer, because cold air being heavy, settles on the ground where the instruments are; whereas a portion of the cold of radiation formed on the surface of the sea is constantly escaping to depths greater than 6 feet, at which the temperatures are taken.

The great excess of the temperature of the sea over that of the air in the north is perhaps the most remarkable fact in the meteorology of Scotland. It is a difference, moreover, as the following table will show, which may be considered constant from year to year:

	1857.	1858.	1859.	1860.	1861.	1862.	1863.	1864.
Mean annual temperature of sea at Sandwick...	49.5	49.4	49.4	47.5	48.6	48.6	48.8	48.1
Mean annual temperature of air at Sandwick..	47.5	46.0	45.7	44.1	46.3	45.8	46.4	45.5
Mean annual difference..................	2.0	3.4	3.7	3.4	2.3	2.8	2.4	2.6

This Table teaches, if examined closely, the slowness with which changes in the temperature of the air are completely propagated through the waters of the ocean in those northern parts where the power of the sun's rays is greatly diminished. During the first four years the annual temperature of the air continually fell from year to year, as compared with the first year, to the extent of 1°.5 in the second year, 1°.8 in the third year, and 3°.4 in the fourth year; but during the same years the temperature of the sea only fell 0°.1, 0°.1, and 2°.0. In 1861 the air rose 2°.2; but the sea rose only 1°.1, and remained stationary in the next year, while the air fell half a degree. In 1863 air and sea respectively rose 0°.6 and 0°.2; and in 1864 fell 0°.9 and 0°.7.

When the tendency of the temperature of the sea to follow that of the air is considered, it can scarcely admit of a doubt that, if the waters of the sea were stationary round Orkney from year to year, their temperature would ultimately fall to that of the air, or at least to about half a degree of it. But this is not the case; there is some influence at work keeping the temperature of the sea 3°.0 above that of the incumbent air. The enormous amount of heat sufficient to maintain the whole waters of the sea in the north from 2° to 3° above the air, must be brought from warmer latitudes by currents of some sort or other. Since, then, a sea current from the south must be conceded, what is the agent employed?

In answering this question it is impossible to avoid the discussion of the Gulf Stream. The two questions presented are: Will a surface-current, generated by the prevailing S. W. winds, be sufficient to account for, not merely the drifting of objects floating on the sea to the northeastward, and stranding them on the coasts of Great Britain and Norway, but for maintaining the temperature of the sea in the north of Scotland 2° or 3° above that of the air? Or, to explain the phenomenon, must we have recourse to that mighty ocean current which, issuing from the Straits of Florida, flows northward to Newfoundland, and then spreads itself eastward over the Atlantic?

Let it be assumed that a surface-current of warm waters is brought from warmer latitudes by the S. W. winds sufficient for the purpose. In this case we should expect at no great depth a great difference between the temperature and that of the surface. The observations at 60 feet deep, as compared with 6 feet, (see Table III,) do not countenance this supposition. Though they unfortunately extend only over four months, yet so far as they go they point to an equality in the mean annual temperature at those depths. But, again, *if a current to the northeast be produced by the S. W. winds, that current must necessarily be fed from some source to the S. W. of Great Britain, somewhere in the Atlantic between Spain and America.* Now, as is well known, two great currents are constantly pouring their water into this space; the one bringing the cold water of the Arctic regions, the other the warm waters of the Tropics; and the line of their junction is in certain places so well marked that, in crossing it in May, 1861, Admiral Sir Alexander Milne found the temperature at the stern of H. M. S. Nile to be 40°.0, and at the bow 70°.0, the difference being 30°.0. Since the tendency of the Arctic Current, on account of its greater density, is to become an under-current and be overlaid by the warmer, and therefore lighter current, it is only fair and reasonable to suppose that that current which flows northward past the shores of Great Britain is fed by the warm waters of the Gulf Stream; in other words is part of it. Its passage is no doubt slow; but we have seen from the slow rate at which the temperature of the sea is brought to a complete correspondence with that of the air, that though it took some months to traverse the distance from Wigtownshire to Orkney, it would still carry with it enough of its original heat to keep its temperature above that of the air. **Note. 25.** (Con'd.)

Additional matter bearing on this interesting discussion has just appeared in the *Twelfth Number of Meteorological Papers*, published by authority of the Board of Trade. In the first chart, the mean temperature of the surface water of the ocean, of each square of ten degrees of latitude and longitude, is given. From this chart it appears that if a line be drawn from Cuba through the Atlantic, in the direction of the Faroe Islands, it will pass through higher temperatures than prevail to the eastward or westward of it—a circumstance pointing to a general flow of the waters in that direction northward.

Mean Temperature of the Months at the different Stations.

The chief point of interest, under this head, is the difference which obtains between the temperature of the Atlantic and that of the North Sea, during the summer and winter months. From October to March the west is at least 2° above the east, and in January it amounts to 3°.9. It is an event happening only once in a number of years, for the temperature of the sea in the west to fall below 40°; but in the east this happens every year, and in February of the present year it fell to 33°.7. It is to this high winter-temperature that the west owes the excellence of its winter-climate, as is evinced by the low rate of mortality during this season, and the luxuriant growth of many of the less hardy plants in the open air.

In May, June, July, and September the temperature of the North Sea is about a degree above that of the Atlantic, which is of course due to the heat

Note.

25. absorbed by the continent of Europe in summer, and to the comparative shallow-
(Con'd.) ness of the North Sea. The mean temperature of the sea being 2° or 3° colder than the air from May to August, moderates to a marked degree the summer-climate of the British Islands.

The maximum and minimum for the year occur earlier in the east than in the west, and earlier in the west than in the north. In Orkney these periods are delayed fully a month; and it is remarkable that, in these northern parts, the temperature of the sea is about as high in September as in August, as high in October as in July, and nearly as high in December as in May.

Note. 25. (Con'd.)

TABLE I.—*Observations of sea temperature at Sandwick, Oban, Otter House, Westhaven, North Berwick, and Dunbar, compared with those taken on the same days at Harris, from November, 1858, to November, 1863.*

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
Harris	44.6	43.6	43.6	44.9	47.8	51.8	54.4	54.9	54.0	51.4	48.2	46.5	48.8
Sandwick	44.8	43.8	43.3	44.1	47.0	50.1	52.9	54.6	54.8	52.4	49.0	46.9	48.6
Difference	+ 0.2	+ 0.2	− 0.3	− 0.8	− 0.8	− 1.7	− 1.5	− 0.3	+ 0.8	+ 1.0	+ 0.8	+ 0.4	− 0.2
Harris	44.4	43.1	43.5	44.7	48.5	52.5	54.6	55.3	53.7	51.8	48.5	45.9	48.9
Stornoway	44.7	43.4	43.6	45.3	49.3	51.9	55.4	55.0	54.5	51.4	48.2	45.7	49.1
Difference	+0.3	+ 0.3	+ 0.1	+ 0.6	+ 0.8	− 0.6	+ 0.8	− 0.3	+ 0.8	− 0.4	− 0.3	− 0.2	+ 0.2
Harris	44.7	44.5	43.7	45.5	47.9	52.1	54.5	55.3	54.3	51.8	48.0	46.5	49.1
Oban	44.7	43.7	43.2	44.4	47.1	51.2	53.5	55.1	54.8	52.9	49.6	46.5	48.9
Difference	0.0	− 0.8	− 0.5	− 1.1	− 0.8	− 0.9	− 1.0	− 0.2	+ 0.5	+ 1.1	+ 1.6	0.0	− 0.2
Harris	44.6	43.3	43.5	44.9	48.5	52.5	54.9	55.2	53.9	51.1	48.2	46.3	49.0
Otter House	44.1	43.2	43.8	45.6	49.6	53.0	54.6	55.2	54.2	50.8	48.1	46.3	49.1
Difference	− 0.5	− 0.1	+ 0.3	+ 0.7	+ 1.1	+ 0.5	− 0.3	0.0	+ 0.3	− 0.3	− 0.1	0.0	+ 0.1
Harris	44.7	43.1	43.7	44.6	47.1	51.5	55.1	55.1	53.7	51.7	48.5	46.7	48.8
Westhaven	41.3	41.6	42.5	46.4	51.3	55.0	58.3	57.9	55.3	49.2	44.8	43.1	48.8
Difference	− 3.4	− 1.5	− 1.2	+ 1.8	+ 4.2	+ 3.5	+ 3.2	+ 2.8	+ 1.6	− 2.5	− 3.7	− 3.6	0.0
Harris	45.2	43.4	43.8	45.0	47.2	51.8	54.3	55.8	53.7	51.4	48.2	46.6	48.9
Dunbar	41.1	40.1	41.7	44.5	48.2	52.4	55.4	55.8	54.8	50.7	46.2	42.9	47.7
Difference	− 4.1	− 3.3	− 2.1.	− 0.5	+ 1.0	+ 0.6	+ 1.1	0.0	+ 1.1	− 0.7	− 2.0	− 3.7	− 1.2
Harris	44.2	42.7	43.4	44.3	47.1	51.9	55.2	55.8	53.4	51.8	48.2	45.7	48.6
North Berwick	40.5	40.0	41.1	44.2	47.8	52.2	55.6	55.6	54.8	50.9	45.5	42.2	47.5
Difference	− 3.7	− 2.7	− 2.3	− 0.1	+ 0.7	+ 0.3	+ 0.4	− 0.2	+ 1.4	− 0.9	− 2.7	− 3.5	− 1.1

Note.
25.
(Con'd.)

TABLE II.—*Mean daily range of the temperature of the sea and the air at Harris, from observations made on the 21st or 22d of each month, beginning 21st May, 1859, and ending 21st November, 1863.*

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Winter.	Spring.	Summer.	Autumn.	Year.	Correction for range.
Mean temperature of sea at—																		
6 a. m.	42.9	43.0	43.6	44.2	48.5	52.7	55.0	55.0	53.5	50.3	48.3	45.8	43.9	45.4	54.2	50.7	48.57	+ .19
8 a. m.	43.1	43.0	43.7	44.3	48.8	53.1	54.9	54.9	53.6	50.4	48.6	45.8	44.0	45.6	54.3	50.9	48.68	+ .08
9 a. m.	43.3	43.0	43.6	44.4	48.9	53.1	55.0	54.9	53.8	50.3	47.7	45.9	44.1	45.6	54.3	50.6	48.68	+ .08
10 a. m.	43.7	43.0	43.7	44.5	49.0	53.1	55.0	55.0	53.8	50.2	47.3	46.1	44.2	45.7	54.4	50.4	48.70	+ .06
Noon	43.7	43.0	43.8	44.5	49.1	53.1	55.4	55.1	53.9	50.2	47.6	46.1	44.3	45.8	54.5	50.6	48.79	— .03
2 p. m.	43.5	43.1	43.8	44.7	49.0	52.7	55.5	55.3	54.0	50.4	47.9	45.9	44.2	45.8	54.5	50.8	48.82	— .06
3 p. m.	43.7	43.1	43.9	44.9	49.0	52.9	55.5	55.2	54.0	50.5	47.7	46.0	44.3	45.9	54.5	50.7	48.87	— .11
4 p. m.	43.5	43.2	43.8	45.1	49.1	52.8	55.4	55.4	53.8	50.6	47.9	46.1	44.3	46.0	54.5	50.8	48.89	— .13
6 p. m.	43.0	43.2	43.7	45.0	49.1	52.9	55.3	55.3	53.8	51.0	47.4	46.1	44.1	45.9	54.5	50.7	48.82	— .06
8 p. m.	43.3	43.2	43.6	44.8	49.2	52.9	55.2	55.1	53.7	50.6	47.5	46.1	44.2	45.9	54.4	50.6	48.77	— .01
9 p. m.	43.4	43.2	43.6	45.0	49.2	53.1	55.3	55.1	53.7	50.4	47.8	46.2	44.3	45.9	54.5	50.6	48.83	— .07
10 p. m.	43.5	43.1	43.6	44.8	49.3	53.0	55.4	55.0	53.8	50.3	48.1	46.1	44.2	45.9	54.5	50.7	48.83	— .07
Midnight	43.8	43.0	43.6	45.0	48.9	52.8	55.1	55.0	53.9	50.4	48.6	45.9	44.2	45.8	54.3	51.0	48.83	— .07
2 a. m.	43.8	43.1	43.5	44.8	48.6	52.4	54.8	55.1	53.6	50.5	48.6	45.9	44.3	45.6	54.1	50.9	48.73	+ .03
3 a. m.	43.6	43.1	43.5	44.9	48.4	52.3	54.6	55.0	53.5	50.6	48.6	46.1	44.3	45.6	54.0	50.9	48.68	+ .08
4 a. m.	43.4	43.1	43.6	44.7	48.5	52.3	54.4	54.9	53.4	50.6	48.6	46.1	44.2	45.6	53.9	50.9	48.63	+ .13
6 a. m.	43.4	43.0	43.5	44.7	48.4	52.5	54.6	55.0	53.3	51.0	48.8	46.0	44.1	45.5	54.0	50.8	48.62	+ .14
Mean	43.5	43.1	43.7	44.7	48.9	52.8	55.1	55.1	53.7	50.5	48.0	46.0	44.2	45.7	54.3	50.7	48.76	....

Note 25. (Con'd.)

TABLE II.—*Mean daily range of the temperature of the sea and the air at Harris, from observations made on the 21st or 22d of each month, beginning 21st May, 1859, and ending 21st November, 1863*—Continued.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Winter.	Spring.	Summer.	Autumn.	Year.	Correction for range.
Mean temperature of air at—																		
6 a. m	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
8 a. m	42.1	43.0	38.4	43.1	50.8	52.4	55.0	56.0	51.0	49.5	45.7	41.9	42.3	44.1	54.5	48.7	47.4	+ .6
9 a. m	42.2	43.6	39.2	45.0	52.2	53.2	58.4	57.5	51.8	48.9	46.8	42.1	42.6	45.5	56.4	49.2	48.4	— .4
10 a. m	42.5	44.5	41.1	45.9	53.6	54.1	60.0	59.2	52.4	49.0	47.1	42.5	43.2	46.9	57.8	49.5	49.3	—1.3
Noon	43.0	44.7	44.2	47.0	55.3	54.7	60.6	57.5	53.7	50.0	48.2	42.5	43.4	48.8	57.6	50.6	50.1	—2.1
2 p. m	43.2	45.2	46.4	48.7	55.3	55.1	60.9	58.8	55.2	50.8	46.1	42.6	43.7	50.1	58.3	50.7	50.7	—2.7
3 p. m	43.1	45.7	46.2	49.5	55.1	56.5	62.3	59.0	54.8	50.4	45.8	42.2	43.7	50.3	59.3	50.3	51.9	—3.9
4 p. m	42.7	42.2	45.2	50.7	55.3	56.4	61.9	59.8	53.9	49.0	45.5	41.5	42.1	50.4	59.4	49.5	50.3	—2.3
6 p. m	43.0	42.8	41.4	46.6	54.4	55.4	58.2	58.5	51.7	49.0	44.7	41.6	42.5	47.5	57.4	48.5	48.9	— .9
8 p. m	42.4	42.8	40.0	43.3	50.5	54.0	54.8	55.6	51.7	48.3	45.5	42.0	42.4	44.6	54.8	48.5	47.6	+ .4
9 p. m	42.5	43.1	39.9	43.0	48.8	52.9	53.4	54.7	51.3	48.1	46.0	42.1	42.6	43.9	53.7	48.5	47.2	+ .8
10 p. m	42.6	42.3	39.3	43.2	48.2	52.7	52.7	54.2	51.3	48.7	46.2	41.4	42.1	43.6	53.2	48.7	46.9	+1.1
Midnight	42.1	42.0	39.5	43.0	46.8	52.3	52.0	54.2	51.1	49.1	45.3	42.1	42.1	43.1	52.8	48.5	46.6	+1.4
2 a. m	42.9	41.8	38.1	42.7	46.6	52.1	50.7	53.8	51.1	48.8	44.0	42.0	42.2	42.5	52.2	48.0	46.2	+1.8
3 a. m	43.7	41.9	38.0	42.9	46.7	51.8	50.2	53.8	50.9	48.7	43.0	41.8	42.5	42.5	51.9	47.5	46.1	+1.9
4 a. m	44.1	42.5	38.0	42.4	47.0	51.9	50.4	53.6	51.2	48.4	43.7	41.2	42.6	42.5	52.0	47.8	46.2	+1.8
6 a. m	44.5	42.9	39.6	41.9	50.0	52.1	53.2	53.5	50.8	49.1	42.9	41.7	43.0	43.8	52.9	47.6	46.8	+1.2
Mean	42.8	43.1	40.8	44.5	50.9	53.5	55.8	56.1	51.9	49.1	45.4	41.8	42.6	45.4	55.0	48.8	48.0	......

Note. 25. (Con'd.)

TABLE III.—*Showing the temperature of the sea at Harris (Outer Hebrides) from observations made from June, 1858, to November, 1863, inclusive. 1. At depth of 6 feet; 2, at depths of 1 and 24 feet; and 3, at depths of 6 and 60 feet.*

Temperature.	Date.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
I.—At the depth of 6 feet.														
Mean temperature at 9 a. m.	Nov., 1858–Nov., 1863.	44.68	43.39	43.49	44.68	47.92	51.94	54.82	55.35	54.10	51.61	48.27	46.38	48.92
Mean temperature at 3 p. m.	Nov., 1858–Nov., 1863.	44.75	43.42	43.66	45.11	48.35	52.32	54.94	55.61	54.36	51.74	48.30	46.70	49.13
Mean temperature at 9 p. m.	Nov., 1858–Nov., 1863.	44.55	43.37	43.49	44.96	48.29	52.31	54.92	55.46	54.31	51.53	48.01	47.88	49.14
Mean of daily minima	Nov., 1858–Nov., 1863.	44.13	43.03	43.28	44.53	47.65	51.60	54.25	55.07	54.00	51.24	47.81	45.88	48.56
Mean daily range	Nov., 1858–Nov., 1863.	0.62	0.39	0.38	0.58	0.70	0.72	0.69	0.54	0.36	0.50	0.49	0.82	0.57
Extreme temperature, highest	Nov., 1858–Nov., 1863.	47.6	46.1	45.6	49.5	53.8	57.3	58.4	58.6	56.9	54.7	52.2	49.6	58.6
Extreme temperature, lowest	Nov., 1858–Nov., 1863.	39.1	39.1	39.9	41.8	44.1	46.7	50.2	52.1	51.1	44.6	40.9	40.4	39.1
Difference, or extreme range	Nov., 1858–Nov., 1863.	8.5	7.0	5.7	7.7	9.7	10.6	8.2	6.5	5.8	10.1	11.3	9.2	19.5
Highest monthly mean temperature	Nov., 1858–Nov., 1863.	45.6	44.8	44.3	45.9	49.2	53.6	56.8	57.4	55.6	53.3	49.4	47.6	57.4
Lowest monthly mean temperature	Nov., 1858–Nov., 1863.	43.2	41.2	42.3	43.3	45.7	50.2	52.0	53.4	52.4	50.7	47.1	44.6	41.2
Greatest monthly range	Nov., 1858–Nov., 1863.	8.5	4.2	3.5	6.0	9.0	7.4	6.1	5.0	4.0	9.4	9.8	6.8	9.8
Least monthly range	Nov., 1858–Nov., 1863.	3.1	2.8	1.2	2.2	3.4	4.6	4.1	3.0	2.7	2.5	4.2	3.5	1.2
Mean monthly range	Nov., 1858–Nov., 1863.	5.3	3.4	2.4	4.5	6.0	6.1	5.0	4.2	3.3	5.8	7.1	5.7	4.9
II.—At depths of 1 and 24 feet.														
Mean temperature at 1 foot, 8.45 a. m.	June–Oct., 1858.	...	...	...	...	...	54.06	55.82	57.63	54.80	49.49	...	...	...
Mean temperature at 24 feet, 8.45 a. m.	June–Oct., 1858.	...	...	...	...	...	53.78	55.93	57.60	55.92	50.30	...	...	...
Mean temperature at 1 foot, 3 p. m.	Sept.,–Oct., 1858.	...	...	...	...	...	...	...	...	55.16	49.55	...	...	...
Mean temperature at 24 feet, 3 p. m.	Sept.,–Oct., 1858.	...	...	...	...	...	...	...	...	55.93	50.43	...	...	...
Mean temperature at 1 foot, 8.45 a. m.	June–Aug., 1858.	...	...	...	...	...	55.07	56.78	58.20	...	...	...	...	...
Mean temperature at 24 feet, 8.45 a. m.	June–Aug., 1858.	...	...	...	...	...	54.28	56.32	57.80	...	...	...	...	...
Highest temperature at 1 foot	June–Oct., 1858.	...	...	...	...	...	58.6	60.0	60.5	61.5	56.1	...	...	...
Highest temperature at 24 feet	June–Oct., 1858.	...	...	...	...	...	58.0	59.0	59.6	61.2	53.0	...	...	...
Range, 1 foot	June–Oct., 1858.	...	...	...	...	...	7.4	6.5	4.5	9.5	9.1	...	...	...
Range, 24 feet	June–Oct., 1858.	...	...	...	...	...	7.5	4.0	3.8	8.2	4.9	...	...	...

Note. 25. (Con'd.)

TABLE III.—*Showing the temperature of the sea at Harris (Outer Hebrides) from observations made from June, 1858, to November, 1863*—Continued.

Temperature.	Date.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
III.—At depths of 6 and 60 feet.														
Mean temperature at 6 feet, 9 a. m.	June-Sept., 1859						53.54	56.84	57.40	55.64				
Mean temperature at 60 feet, 9 a. m.	June-Sept., 1859						52.78	55.78	56.89	56.28				
Mean temperature at 6 feet, 3 p. m.	June-Sept., 1859						54.03	57.15	57.70	56.00				
Mean temperature at 60 feet, 3 p. m.	June-Sept., 1859						52.76	55.76	56.95	56.29				
Mean temperature at 6 feet, 8 p. m.	June-Sept., 1859						53.63	57.17	57.50					
Mean temperature at 60 feet, 8 p. m.	June-Sept., 1859						52.66	55.89	56.89					
Mean of daily minima, 6 feet	June-Sept., 1859						53.08	56.54	56.80	55.40				
Mean of daily minima, 60 feet	June-Sept., 1859						52.35	55.50	56.80	56.21				
Highest temperature at 6 feet	June-Sept., 1859						56.0	59.3	59.6	57.4				
Highest temperature at 60 feet	June-Sept., 1859						54.5	56.9	57.5	57.7				
Range at 6 feet	June-Sept., 1859						5.4	4.3	4.0	3.0				
Range at 60 feet	June-Sept , 1859						4.6	3.0	1.3	3.0				

Note. 25. (Con'd.)

TABLE IV.—*Observed mean and extreme temperatures of the sea at a depth of 6 feet, from observations made at ten stations on the coast of Scotland, from January, 1857, to August, 1865, inclusive.*

Stations.	Number of years.	Mean temperature.													Extreme temperature.		
		January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.	Highest.	Lowest.	Difference.
West—																	
Sandwick	8½	44.8	43.8	43.4	44.2	46.6	50.2	52.8	54.8	55.0	52.6	49.5	47.3	48.8	57.0	41.5	15.5
Stornoway	8	44.6	43.6	43.6	46.1	48.8	51.7	54.8	55.2	54.9	51.0	48.8	46.1	49.1	58.0	40.0	18.0
Harris	5	44.7	43.4	43.5	44.7	47.9	51.9	54.8	55.4	54.1	51.6	48.3	46.4	48.9	58.6	39.1	19.5
Oban	5½	45.0	43.7	43.1	44.5	47.3	51.4	53.9	55.1	54.8	52.9	49.8	47.0	49.0	59.3	42.0	17.3
Sea west of Oban	5	....	....	....	....	47.4	51.3	53.8	55.1	54.5	....	....	....	....	60.0	....	....
Otter House	6¾	44.3	42.9	43.5	45.8	49.2	52.4	54.8	55.0	54.0	50.9	48.2	46.3	48.9	61.5	40.5	21.0
East—																	
Westhaven	8½	41.3	40.6	42.3	46.3	50.1	55.0	57.5	58.4	56.5	49.8	45.1	43.2	48.8	63.0	36.5	26.5
North Berwick	4¼	41.4	40.6	41.2	43.8	48.1	52.9	56.0	56.6	56.0	51.8	47.5	43.3	48.3	60.0	37.0	23.0
Dunbar	8	41.4	40.3	41.1	44.1	48.6	52.2	55.7	56.3	55.2	51.1	46.6	43.9	48.0	60.0	37.0	23.0
Mean of west	6½	44.7	43.5	43.5	45.1	47.8	51.5	54.2	55.1	54.6	51.8	48.9	46.6	49.0	61.5	39.1	22.4
Mean of east	7	41.4	40.5	41.5	44.7	48.9	53.4	56.4	57.1	55.9	50.9	46.4	43.5	48.4	63.0	33.7	29.3
Trinity Chain Pier	1½	39.4	36.4	38.7	43.8	49.0	53.7	56.0	56.2	53.6	49.6	44.9	43.8	47.1	60.0	33.7	26.3

Note. 25. (Con'd.)

TABLE V.—*Calculated mean temperature of the sea at a depth of six feet at nine stations on the coast of Scotland, on a mean of five years, from November, 1858 to November, 1863, inclusive.*

Stations.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Winter.	Spring.	Summer.	Autumn.	Year.
West—																	
Sandwick	44.9	43.6	43.2	43.9	47.1	50.2	53.3	55.1	54.9	53.4	49.8	46.8	45.1	44.7	52.9	52.7	48.85
Stornoway	45.0	43.7	43.6	45.3	48.7	51.3	55.6	55.1	54.9	51.2	48.0	46.2	45.0	45.9	54.0	51.4	49.05
Harris	44.7	43.4	43.5	44.7	47.9	51.9	54.8	55.4	54.1	51.6	48.3	46.4	44.8	45.4	54.0	51.3	48.89
Oban	44.7	42.6	43.0	43.6	47.1	51.0	53.8	55.2	54.6	52.7	49.9	46.4	44.6	44.6	53.3	52.4	48.72
Sea west of Oban	....	....	....	....	46.3	50.9	53.9	55.1	53.9	....	....	....	....	....	53.3	....	....
Otter House	44.2	43.3	43.8	45.4	49.0	52.4	54.5	55.4	54.4	51.3	48.2	46.4	44.6	45.7	54.1	51.3	49.02
East—																	
Westhaven	41.3	41.9	42.3	46.5	52.1	55.4	58.0	55.7	55.7	49.1	44.6	42.8	42.0	47.0	57.2	49.8	48.99
North Berwick	41.0	40.7	41.2	44.6	48.6	52.2	55.2	55.2	55.5	50.9	45.8	42.9	41.5	44.8	54.2	50.7	47.82
Dunbar	40.6	40.1	41.4	44.2	48.9	52.5	55.9	55.4	55.2	50.9	46.3	42.7	41.1	44.8	54.6	50.8	47.84
Mean of west	44.7	43.3	43.4	44.6	48.0	51.4	54.4	55.2	54.6	52.0	48.8	46.4	44.8	45.3	53.7	51.8	48.91
Mean of east, (N. Berwick; Dunbar)	40.8	40.4	41.3	44.4	48.8	52.4	55.5	55.3	55.4	50.3	45.6	42.8	41.3	44.8	54.4	50.8	47.83
Difference	− 3.9	− 2.9	− 2.1	− 0.2	+ 0.8	+ 1.0	+ 1.1	+ 0.1	+ 0.8	− 1.7	− 3.2	− 3.6	− 3.5	− 0.5	+ 0.7	− 1.0	− 1.08

In the table on page 10 the observations for 1869 are included; hence the difference in its figures from those of the above Table IV.—HYDROGRAPHIC OFFICE.

Notes.

26-30. [26] See the preceding note.

27. [27] Only the observations of Sandwick and Stornoway go as far as 1869; those at the other stations reach only to 1865. Compare Mohn, "Température de la Mér," &c., pp. 3 and 6. Sandwick lies on one of the Orkney Islands, in latitude 59° 2′ N., longitude 3° 48′ W. of Greenwich. It is not marked on the charts generally in use.

28. [28] Journal of the Scottish Meteorological Society, new series, Nos. xix and xx, October, 1864, p. 215.

29. [29] Letter dated Edinburgh, October 4, 1869, (manuscript.)

30. [30] Proceedings of the Royal Geographical Society. London, v, 1860 and 1861, p. 233. The table of Dr. Thorsteinson's observations at Reikiavik was presented to the Society with the following memoir:

Currents and Ice-Drifts on the Coasts of Iceland. By Captain C. Irminger, of the Danish Navy.

In the northern part of the Atlantic Ocean the surface-water sets steadily with a gentle flow toward the north. Coming, as it does, from more heated regions, and being constantly provided by fresh supplies of heated water, it maintains, as is well known, a moderating influence on the climate of the coasts which are washed by it.

Between Iceland and Norway this current takes a northeasterly direction to the Icy Sea, but without touching the extreme eastern coast of Iceland. It tempers the climate of the Faroe Islands, Shetland, &c., and its influence is so considerable on the coasts of Norway that harbors, even up to the North Cape, (which is in about 71° latitude N.,) admit shipping the whole year round; while in the coldest time of winter it is only the innermost of the smaller bays in the fiords that are covered with ice.

To the westward of the meridian that halves Iceland, the current from the south runs in a northwesterly, or even more northerly direction, until it is stopped by the current from the sea around Spitzbergen. This "Arctic current" runs southwest; it passes the northwest coast of Iceland on its way to Greenland, along whose coast it makes its way, and rounds Cape Farewell. The first-mentioned current from the Atlantic Ocean washes the southwest and west coasts of Iceland, and is found to run true N. 33° W., at the rate of 1.19 nautical miles in 24 hours, throughout an area extending between longitude 18° W., latitude 62° N., and the south coast of Iceland toward Cape Reikianäs; but, west of Iceland, between latitudes 64° 15′ and 65° 50′ N. and longitudes 23° 51′ and 25° 48′ W., to run N. 15° W., at 4.8 nautical miles in 24 hours.

During a protracted stay on the west coast of Iceland, I had frequently been convinced of the fact, well known to fishermen there, that the current along the west coast of Iceland, in addition to a regular ebb and flood, considerably preponderates toward the north.

The annexed table, representing the temperature of the surface of the sea in June, 1846, shows where the warmer current, running northward on the west side of Iceland, met the cold current from the Icy Sea off the northwest coast of Iceland. The man-of-war brig, St. Croix, Captain Suenson, found the temperature of the sea— **Note. 30.** (Con'd.)

Date.	Latitude N.	Longitude W.	Fahrenheit.
1846.	° ′	° ′	°
June 23, 6 p. m.	65 54	25 05	49.1
June 24, 6 a. m.	66 22	26 13	35.6*
" " 9 a. m.	66 30	26 14	32.5
" " noon	66 17	25 39	37.6
" " 4 p. m.	66 53	25 11	46.4
" " 8 p. m.	65 38	24 17	47.5

* Drift ice in sight to the N. E.

The current which comes from the Atlantic not only moderates the climate of the southwesterly and westerly coasts of Iceland, but is also the cause why the so-called "Greenland ice," which is constantly found driving toward Greenland and along its eastern shores, does not visit the west and south coasts of Iceland. There, even if the greater part of the fiords and coves should be frozen up in a severe winter, the fishermen can keep their fishing going throughout the whole year in the two great bays, Faxe- and Brede-bugt, because these bays never freeze up, owing to the influence of the warm Atlantic current. Again, although the days in the latitude of Iceland are very short in winter, and the weather stormy, yet the vessel that carries the mail has succeeded, even in the middle of winter, in carrying on its voyages with regularity between Havne Fiord (at Faxebugt) and England. It has never been stopped, either by the Greenland ice or by the ice from the fiords or the coves.

Warm currents do not moderate the climate of the northwest, north, and east coasts of Iceland; on the contrary, these parts of the island are exposed to the cold currents from the Icy Sea, which frequently bring ice from the sea and around Spitzbergen, by which navigation is frequently impeded to the greater part of the harbors here situated.

Though ebb and flood exist on all the coasts of Iceland, yet the current prevails from west to east near the north coast; possibly the cause of this is that a portion of the Arctic current impinges against that part of the northwest coast of Iceland which turns its face to the Icy Sea, and produces an eddy which runs to the eastward along the north coast of Iceland, in a nearly opposite direction to the principal stream of the Arctic current farther north.

Likewise, on the east coast of Iceland, the current is chiefly formed by an eddy prevailing, in certain seasons at least, to the southward—a direction nearly contrary to the principal current which, as before mentioned, sets to the northeast between Iceland and Norway. The wind has, however, much influence on the direction of this coast-eddy; for though it is usually much easier to beat to the southward than northward, through the help of this current, yet it does not escape the attention of the fishermen, who every year are lying on the fishing-banks along the east coast, that the current may prevail to the north when there is blowing weather from the southwest and south.

To give an idea of the force of the Arctic current, I only need to call to mind

Note.
30. (Con'd.) some of the many whalers which, while being beset in various times, were carried along by it, together with the ice in which they were imbedded.

For instance, in 1777, many whalers were inclosed by the ice between Spitzbergen and Jan-Mayen, and they were driven, while beset, in four months to Cape Farewell, a distance of 1,400 nautical miles, with an average speed of between 11 and 12 miles in 24 hours.

W. Scoresby mentions (Vol. I, p. 213) several cases in which ships, being beset between Spitzbergen and Greenland, were drifted along with the ice toward the southwest or southwest by south. One was a case in which a vessel drifted 182 miles in 13 days, giving a mean of 14 miles per 24 hours; another, in 9 days 120 miles, or 13 miles in 24 hours; a third, 420 miles in 49 days, or 8.7 miles in 24 hours; and a fourth case, 1,300 miles in 108 days, averaging 12 miles per day. The mean of all these cases gives 11.9 miles in 24 hours; and it can therefore be assumed, without much risk of error, that the mean rapidity of the Arctic current is 11 or 12 miles in 24 hours, at least during the season of navigation.

It is a well-known fact that the situation of the ice in the Icy Sea is subject to considerable changes from one year to another, for where an impenetrable ice-barrier was found in one year, vessels could sail in another year several degrees farther without being stopped by the ice; and, on the other hand, where the sea was void of ice in one year, it might be impossible to penetrate so far north in the succeeding one.

The amount of the ice-drift may thus be very different one year from another, and in proportion as the masses are greater which are carried away by the Arctic current from the Icy Sea, the more will the strait between northwest Iceland and Greenland become filled with it. Ice is nearly always met with here by fishermen, who ply every year from the harbors of the northwest coast of Iceland; they usually fall in with drift-ice in the strait between Iceland and Greenland, at from 40 or 60 to 80 miles from Iceland.

This ice-drift is frequently much more considerable. In such cases it fills not only the strait between the northwest coast of Iceland and Greenland, so that for long together it is impossible to round Cape North, but it also incloses the whole coast to unknown limits northward and far to the eastward. To give an idea of the vast extent of an ice-drift like this, I may mention that the distance between Iceland and Greenland is at least 160 nautical miles, and assuming the rapidity of the current at only 11 miles in 24 hours, it will follow on calculation that a mass of ice of not less than between 1,700 and 1,800 square nautical miles in area will have been carried away to the southwest every 24 hours from between northwest Iceland and Greenland.

This so-named Greenland drift-ice consists for the greater part of fields of ice, often piled on one another; these have been produced on the surface of the sea, sometimes to a thickness of five or six fathoms. Secondly, it consists of swimming icebergs, loosened from glaciers, and fallen into the sea. Their size is sometimes so considerable that they have been seen grounded in more than 80 fathoms water.

When this ice, carried by the Arctic current, arrives at the coasts of Iceland, it brings with it a cold very prejudicial to vegetation. Usually the ice appears first on the coast near Cape North; it then drifts on the northwest coast inclosing the fiords between Patricks and Ise-Fiord; and it will happen, though rarely, that part of this ice passed Fugle or Staalbierghuk, and drives in the direction of Bredebugt. The north coast of Iceland is then more or less inclosed; a considerable drift sets down to the bay of Skagestrand, and occasionally reaches even to the eastward of Langenaes, whence the current carries it upon the east coast of the island; and as the ice on the north as well as on the east coast is usually more compact than off the northwest fiords, the navigation there is sometimes wholly impeded from January to February until the following summer-time. When there is much ice on the east coast of Iceland, it may happen that some of it will drive round the south side of the island, though this never hinders navigation to the western coast. Note. 30. (Con'd.)

The quantity of the ice, as well as the periods of its coming and leaving the coasts of Iceland, are very different. Some years a great part of the coasts are inclosed by it; other years it does not appear at all. Very seldom it comes before January or February; most frequently it comes in spring, and sometimes a little later. It is remarkable that the ice, even when the masses which inclose the coasts of Iceland are very considerable, always leaves the coasts by August at the latest.

That not only the ice-drift, but also the severity of the winters of Iceland are very different in different years, is well known from ancient and recent observations. Thus the annals of Iceland state in reference to the year 1348: "The winter was so severe that the sea was frozen around the island; it was possible to ride from one neck of the land to another, and all the fiords were frozen up with ice." In the year 1615 it is mentioned "that the Greenland-ice inclosed the island in such a way that seals (Vade Sacle, a species of the seal following polar ice) were caught in 'South on the Nazes;' a great quantity of bears did likewise then come to the country, and some of them were killed on the south side of it; many large vessels, which were visible from the land, perished with crew and all."

Considerable ice-drifts have occurred in recent times. From notes communicated to me by Mr. Thorlacius, living at Stikkelsholm, on the Bredebugt, by Mr. Sigurdson and by others, I find that the Greenland-ice drifted into the northwest fiords (between Staalbierghuk and Cape North) late in December, 1858, and in January, 1859, and that about the same time ice appeared on the north and east coasts of Iceland, but left them a short while after. In February and March it returned, and inclosed the shore from Staalbierghuk to Cape North, also the whole north coast, even to the eastward of Langenaes, and, lastly, a considerable part of the east coast, whence masses of ice drove along to the south side of Iceland, passing Portland and Reikianäs. The fiords from Staalbierghuk, around the whole north coast and for some distance down the east coast, were filled with Greenland-ice which froze into a single mass with the winter-ice in the fiords, and in consequence the ice did not break up in the northwest fiords before May; in the bay of Skagestrand not before June.

Still it seems that there was even more ice in 1807. The annals of this year mention, in addition to nearly the same facts as those observed in 1859, that "from the most elevated mountains on the north and east coasts no open water was visible; that the inhabitants from Grimsöe, which lies more than twenty nautical miles from the north coast of Iceland, went in spring over the Greenland-ice to the trading place Ofiord, and that several pieces of that ice were carried from

Note.
30. (Con'd.) the east coast round the south coast, and were seen in Faxebugt and Bredebugt; a state of things which nobody could remember to have seen before."

As ice-drifts along the south coast are unusual, I take the liberty to mention some other cases, the more readily as they confirm what I have already said on the setting of the current along this part of the coast of Iceland.

Mr. Abel, who was "Sysselmand" (functionary) in Westmanoe from 1821 to 1851, writes to me as follows: "On the 26th of May, 1826, with calm and clear weather, a great quantity of ice was discovered from Westmanoe driving with a speed of three or four miles an hour from Portland along the coast to westward. When it came near to Elleroe and Biarneroe, two little islands between Westmanoe and the south coast of Iceland, several of the icebergs grounded to the east and southeast of them, and some larger icebergs grounded to the southward of Biarneroe in sixty fathoms water. The mass of ice entirely covered the sound between Westmanoe and Iceland, being about eight nautical miles in width, while it was not possible to discover how far that part of the ice stretched which passed to southward around Westmanoe. The passage of this ice-drift from beginning to end lasted between four and five hours. During a continuance of calm and clear weather and a perfectly smooth sea some majestic icebergs which had grounded remained in their places; now and then they changed their form, when considerable pieces broke loose and plunged in the sea. At last, on the 8th or 9th of June, a high swell carried off these remaining icebergs in the same westerly direction as the former ice."

Mr. Abel mentions that the oldest inhabitants had never seen such an ice-drift from Westmanoe, and that none had subsequently appeared, excepting a few fragments of Greenland-ice in one year, (the exact date is not mentioned, but between 1830 and 1840,) and also in the year 1840. He further remarks that during his thirty years' residence on Westmanoe he never had found it so cold as during the ice-drift of 1826. The window panes in his sitting-room were entirely frozen, and it was not possible to thaw them by heat from the stove.

Undoubtedly the year alluded to by Mr. Abel as between 1830 and 1840 must have been 1834; for the present Bishop Thordersen, at Reikiavik, whom I visited at Odde very many years ago, where he was then the minister, writes to me: "During my residence at Odde, from 1825 to 1836, I saw twice from my house the Greenland-ice drive between Westmanoe and the continent with considerable rapidity to westward. It was an imposing view. When the ice was first seen by the naked eye it had the appearance of large vessels; but with the telescope I soon discovered it to be icebergs accompanied by great masses of field-ice. I can only recollect the date of one of these two years with certainty; it was 1834; the other year I have forgotten; but I recollect that, when traveling to Reikiavik in the autumn of the year I do not remember, (1826?) I saw at Orebak one of these icebergs which accidentally had stranded there, and which had, as well as I can remember, a height of at least 8 feet above the surface of the sea, even after the heat of summer."

In 1859 an ice-drift again passed Westmanoe. Some ice grounded at the entrance of the harbor and entirely blocked it for several days. This event must be considered a very rare one.

It is not improbable that the very considerable ice-drift of 1826, which, calculating from the data given above, must have covered an area of at least two hundred square miles, may have been accompanied by polar bears as well as by seals. These animals, as is well known, are found very frequently on polar ice, and are carried away with it on its drift to the southward, and therefore it would not have been impossible that some of these animals, as in 1615, might have been killed "on the southern headlands of Iceland." Note. 39. (Con'd.)

The reports of the year 1807, that some flakes of Greenland-ice had been seen in the Faxebugt and Bredebugt, having come from the east coast round the south side of the island, can perhaps be explained thus: that the ice, after having passed Reikianäs, and followed the run of the current in a northwesterly direction, was conveyed to the Faxebugt and Bredebugt by continual gales from the west.

This ice is a great rarity in the Faxebugt, but when it is known that stormy weather has influence on the usual direction of currents, and that about one-ninth of the driving ice is above the surface of the sea, and exposed to the immediate action of the wind, it may well happen that pieces of ice should appear where no such ice had previously been seen in the memory of men.

Besides repeated stays of long duration at several places on the south coast of Faxebugt, I have traveled on the south side of Bredebugt and the north side of Faxebugt, by proceeding from Stikkelsholm, traveling to Gronne Fiord and Olufsvig, and going around the Snefelsjökul to Stappen, Budenstad, Miklaholt, &c. Everywhere I interested myself in obtaining a knowledge of the drift of the Greenland-ice, and asked frequently if it was ever seen from any of these places, but always received an answer in the negative. However, Mr. Olausen, who resided at Olufsvig during many years, communicated to me that, in 1830 or 1831, he had heard from an old man, who at that time lived at Olufsvig, that he could remember once, when a child, to have seen an iceberg stranded in the Bredebugt north of Gronne Fiord. This iceberg lay grounded for some time; it came nearer the coast during a spring-tide in May and disappeared after the first spring-tide in June. According to the age of the informant it is not improbable that this happened in 1777, the year when so many whalers were lost in the enormous masses of ice which were driven southwest, between Iceland and Greenland.

I have taken the liberty of speaking minutely about the rare occurrence of ice on the west coast of Iceland, because a renowned English author had mentioned that intelligence had come to his notice that all the bays and creeks of Iceland, in 1816 as well as in 1817, were filled with Greenland-ice. According to the accounts given by me above this cannot have been the case, at least so far as the Faxebugt and Bredebugt are concerned.

In recent times there are proofs that polar bears have come with the Greenland-ice to the northwest and north coasts of Iceland, where this ice is so frequent. In a letter from Mr. Thordersen I see that such a polar bear was shot in Strande-Syssel a few years ago. There are traditions in Iceland that these bears now and then have killed cattle, and done other mischief; but usually they, like the bear killed in Strande-Syssel, have been of a peaceable nature, and it is a common saying in Iceland that the bears constantly watch the opportunity to get off with the ice; as soon as it leaves the coast they swim out to reach it.

According to information I have received, Iceland has been visited by the Greenland-ice thirty-three times between the years 1800 and 1860 inclusive. On every occasion it came to the north coast, which was beset by it, and on nearly

Note.
30. (Con'd.) every occasion, during these thirty-three years, the coast between Cape North and the bay of Skagestrand was beset by it. Thirteen times it inclosed the *whole* of the north coast to Langenaes, and even farther to the eastward; fourteen times it lay outside the northwest fiords between Staalbierghuk and Cape North, and blocked them up, (either all or a few of them;) thirteen times ice has appeared on the east coast in various quantities; and in five different years ice has been driven from the east coast to the westward, along the south side of Iceland.

While traveling in North Iceland, I saw the Greenland-ice from the mountains near Vellir for the first time on the 27th of July, 1834. I remember it was extremely clear on that day, and the sun felt very warm when riding on the paths between the mountains of the Northland. When I first came in sight of the Icy Sea, being unaware of the neighborhood of enormous masses of ice, my surprise was so great that I called to my fellow-travelers who were behind me, "What a storm on the Icy Sea!" But what I had presumed to be the foam of the waves and breakers, I soon discovered to be a quantity of the Greenland-ice, by which the whole of the north coast and a considerable part of the east coast were inclosed in that year.

On my return to Reikiavik I inquired if any of the newly-arrived vessels had fallen in with ice, and from many seafarers at Reikiavik, Havne Fiord, and Kieblevik I obtained the answer that neither this year, nor at any time formerly, had they ever fallen in with ice on their voyages to or from those ports. I happened to be in Iceland both in 1826 and 1834, which were two of the five recorded years in which Greenland-ice was driven along the south coast, and notwithstanding that both of these years I spent the greatest part of the summer on the south land of the island, I never heard mention that any seafaring man had fallen in with Greenland-ice on the voyages between Europe and this part of Iceland, which sufficiently proves that ice-drifts, going along the south coast of Iceland, are such insignificant objects in the great ocean that they do not impede navigation in any way.

I have already mentioned that experience teaches that the Greenland-ice, even when it incloses the north and east coasts of Iceland in great masses, always leaves the coasts again in the course of August, if not earlier. I will now inquire into the reason of this, or at least give some hints which may throw light upon the phenomenon.

1. A partial cause may perhaps be found in the melting of ice and snow on the enormous jokuls and snow-covered mountains in the interior of this great island. When traveling in Iceland in the warm season, in which the sun is nearly always above the horizon, it does not escape the traveler's attention that the amount of melted ice and snow is very considerable, and I will try to give a proof of it. At the end of July, 1834, between Holum and Ofiord, I passed Heliardalsheden, which, at the most elevated part of the road, is about 2,000 feet above the level of the sea. From a little glacier here, the Svarfaraa has its source. On following the course of this stream, a great many rivulets, which all had their origin in the melted ice and snow, fell into the Svarfaraa; and in the valley, eight or ten miles from its source, this stream, which does not at all belong to the great water-courses of Iceland, had grown to an extremely rapid river. By considering how small is the area from which the Svarfaraa has its nourishment, we may estimate the very considerable quantity of water which is carried out into the sea, from the whole interior of Iceland, by many other rapid and

greater rivers, and it will not then appear improbable that the melting of the snow, which undoubtedly is greatest in July and August, and the consequent increased flow of the rivers, might contribute to remove the sea-ice farther from the coast. But if the ice from the east coast drifts out to sea within range of the principal current, which runs at a certain distance from shore, it will find its way to the Icy Sea again; for, as I have already mentioned, the principal current between Iceland and Norway is northeasterly, toward the Icy Sea. Again, if the ice which incloses the northern coast of Iceland be drifted out to sea, within range of the great current opposite, it will be carried away between Iceland and Greenland, and farther. **Note. 39.** (Con'd.)

2. It is well known, and confirmed by the excellent charts on storms in the Atlantic by Captain Maury, that June, July, and August are the months in which the Northern Atlantic is least exposed to stormy weather; and, as the prevailing gales in this part of the Atlantic are from the west, it is not improbable that the current coming from the south, and running between Iceland and Norway during the other months, in which the most blowy weather takes place, should, in the calm summer season, run somewhat more westerly and nearer to the eastern coast of Iceland. If so, it would contribute to remove the ice from its shores.

3. It is also well known that the limits of the Gulf Stream are very changeable in the different seasons. Thus, in the meridian of Cape Race, its northern limit in winter is in about north latitude 40° or 41°; while in September, when the Gulf Stream is most heated, it reaches 45° or 46°. (Maury's Sailing Directions, vol. i, p. 99; July, 1858.) It is highly probable that this current changes its position within defined but wide limits; or, as Maury strikingly remarks, the Gulf Stream "may be supposed to waver about in the ocean, not unlike a pennon in the breeze." These variations of its course may extend to the latitude of Iceland, or even still farther north; and perhaps a branch of this stream, in the summer season, may swing somewhat nearer to the east coast of Iceland, and, turning along its north coast, may thus contribute to the ice leaving its shores. On examining the temperature of the surface of the sea on the east and north coasts of Iceland, it appears undoubtedly that the eddy of the Arctic current, along the north coast of Iceland, does not exist in July and August; it is, therefore, probable that that eddy which, during the greater part of the year, runs toward east, is displaced, in the course of the summer, by the current coming from more southerly latitudes. It is likewise remarkable that the temperature of the sea on the east coast of Iceland is not as high as it appears to be along the north coast; and the supposition is reasonable that the warmer current, on bending in a westerly direction, passes Langenaes along the north coast, without touching the shores of East Iceland. It is well known that the surface of the sea, even in high latitudes, can maintain a high temperature. Parry found 39° F. on his voyage, in summer, from Faroe to Spitzbergen, even in latitude 73° N., and longitude 8° E., and I shall corroborate this observation by a fact observed last year.

The schooner Fox, Captain Sodring, left Copenhagen in February, bound to the Icy Sea. An extract from her log-book gives the following:

Note. 30. (Con'd.

Off Lindesnaes in Norway.

Date.	Position.		Temperature, Fahrenheit.		Remarks.
	Latitude N.	Longitude.	Air.	Surface of sea.	
1860.	° ′	° ′	°	°	
February 28	....	....	36.5	37.7	
February 29	58 32	4 22 E.	38.8	38.8	
March 1	59 40	3 40 E.	37.0	41.0	
March 3	61 56	0 08 E.	41.0	45.5	
March 4	63 57	2 15 W.	39.9	39.9	
March 5	64 40	2 59 W.	34.2	38.1	
March 6	65 15	1 35 W.	38.1	38.8	
March 7	66 21	1 26 W.	34.2	41.1	
March 8	68 31	4 15 W.	33.1	34.2	
March 9	70 30	7 47 W.	32.0	30.9	Between ice in sight of Jan-Mayen.
March 10	....	....	11.7	30.9	

By this it will be seen that the sea, on its surface, near the Polar Circle, even in the beginning of March, and notwithstanding the effects of a long and cold winter, still retained a heat of 41° F.; therefore it is not improbable that a branch of the warmer current is connected with the above-mentioned high summer-temperatures of the north coast of Iceland, and that it possibly displaces the eddy of the cold Arctic current, and helps to remove the Greenland-ice from the coast of Iceland in July and August.

I beg to call attention to this point; further observations will show if my supposition be right or not.

The thermometers used on the voyages to North and East Iceland for determining the temperatures of the surface of the sea, as well as the thermometer used by the Fox, were all verified and delivered by me. The observations will be found noted down in the log-books of the different vessels; and the captains being intelligent men, who all took an interest in their work, I do not doubt the veracity of their observations.

To prove the influence which the warmer currents have on the climate of Reikiavik, (though its harbor is sometimes frozen in severe winters,) in opposition to the climate of Ofiord, situated on the north coast of Iceland and exposed to cold currents from the Icy Sea the greatest part of the year, I add the following tables of temperature of the air:

Reikiavik, 64° 09′ *N.* (*Observations Meteorological in Islandia. Thornsteinson, Hafnia*, 1839.)

Winter.	Spring.	Summer.	Autumn.	Mean for the year.
°	°	°	°	°
29.1	37.0	53.5	37.9	39.4
Ofiord, latitude 65° 40′ N., (Kaemtz, 1832, vol ii, p. 88.)				
23.2	28.2	49.8	34.5	32.3

Difference in latitude, 1° 31′. **Notes. 30-33.**

Difference in annual mean temperature, 7° F.

As a proof of what kind of weather may be met with on the north coast of Iceland, even in summer, I give an extract of Scheel's meteorological observations, which are to be found in his second volume.

Station: A dwelling-house at the innermost part of the Tharalaturs Fiord, between Cape North and Geirolfsgnup:

Date.	Temperature, Fahrenheit.		
	Morning.	Noon.	Evening.
1809.	°	°	°
August 1, gale from northeast	47.7	34.2	30.9
August 2, gale from northeast	33.1	33.1	32.0
August 3, increasing gale	30.9	32.0	33.6
August 4, moderating gale	33.1	32.0	33.8

The memoir closes with the table of observations by Dr. Thorsteinson on the surface of the sea at Reikiavik, which is given on page 13 of this volume.

[31] In Mohn's memoir, Température de la Mér entre l'Islande, l'Écosse et la Norvége, (Christiania, B. M. Bentzen,) =55°.4. 31.

[32] The very extensive and important operations of this institute require annually only the sum of 7,770 francs, which is paid by the Norwegian exchequer. (Report of the Institute, September, 1867, with a chart.) 32.

[33] Communications in manuscript, dated Christiania, September 30 and November 15, 1869. 33.

[Professor Mohn had sent, as appears, in the beginning of 1869, a table of observations to the director of the North German "Seewarte," Dr. von Freeden, who made use of it in an investigation of the diurnal fluctuation in the temperature of the sea in those high regions. The subjoined is an abstract of that table, with remarks of Dr. von Freeden. (Geographische Mittheilungen, 1869, p. 208, foot-note.) The values for the monthly mean temperatures which Dr. von Freeden employs have slightly changed by the subsequent observations, (in 1869,) as will be seen when comparing them with the values recorded by Dr. Petermann.—HYDROGRAPHIC OFFICE.]

I am under obligation to Professor Mohn for a table of daily observations of the temperature of the sea at the meteorological stations of the coast of Norway. From them I find the following monthly means:

Months.	Hellisö.		Ona.	Villa.	Andenes.	Fruholm.		
	8 a. m.	2 p. m.	8 a. m.	8 a. m.	2 p. m.	8 a. m.	2 p. m.	8 p. m.
	°	°	°	°	°	°	°	°
July	53.04	53.73	54.30	55.71	50.27	45.28	45.30	45.73
August	60.17	60.91	57.40	58.08	53.33	48.24	48.51	48.18
September	56.39	57.06	54.45	51.66	47.48	....	47.14	....
Means	56.53	57.23	55.38	55.15	50.36	46.76	46.98	46.95

Note. 33. (Con'd.) While at Hellisö, in latitude 61° N., the mean fluctuation of the temperature between 8 a. m. and 2 p. m. amounts still to 0°.7, the temperature means at Fruholm, in latitude 71° N., are respectively 46°.76, 46°.98, and 46°.95, differing far less than the probable error of observations on board. The daily amplitude on the high sea, moreover, is always smaller than near the coast, on account of the more ready compensation.

In regard to the epoch within which the increasing temperature of July will compensate the decreasing of September, we find the temperature of the sea, at the coast, to reach its mean value of—

56°.5 at 8 a. m., at Hellisö, about the 30th of August;
57°.2 at 2 p. m., at Hellisö, about the 30th of August;
55°.4 at 8 a. m., at Ona, about the 17th of August;
55°.2 at 8 a. m., at Villa, about the 4th of August;
50°.4 at 2 p. m., at Andenes, about the 1st of August;
47°.0 at 2 p. m., at Fruholm, about the 31st of August;

from which there could be deduced, in latitude 65° 40′ N., longitude 12° 25′ E. of Greenwich, for the middle of August, a mean temperature of 53°.2.

From the mean values of the temperatures of the same hours of each day observed on the high sea by the first German North Polar expedition. however, a mean temperature will be found—

at 0 hours of 36°.12;
at 4 hours of 36°.28;
at 8 hours of 35°.98;
at 12 hours of 35°.98;
at 16 hours of 36°.16;
at 20 hours of 36°.16;

which shows conclusively how very small the mean daily amplitude is.

The respective means for June (in the ice near the Greenland coast) were 30°.58, 30°.67, 30°.56, 30°.34, 30°.43, and 30°.34, figures still more satisfactory.

During the last days of May, when northward bound in a sea free of ice, the means for the respective hours of observation were 42°.42, 42°.33, 41°.92, 41°.45, 42°.35, and 41°.34, nearly coinciding in their fluctuation with the temperatures of the air, (43°.77, 43°.05, 42°.49, 40°.95, 40°.80, and 41°.33,) and indicating already the effects of the insolation in the more southern latitudes.

Finally, as the mean temperature of the sea north of the Arctic Circle, from the 1st of July to the 15th of August, was found to be 35°.4, and the same from the latter date to the 25th of September, when the ship recrossed the Arctic Circle, it will be safe to assume the middle of August as the mean epoch, to which the isothermal curves deduced from all the observations of the first German North Polar expedition will apply.

The temperature of the sea, however, varies considerably in the various years. Professor Mohn, for instance, found, in July, 1867, at the North Cape a temperature of the sea of 39°.2, which rose until September to 44°.6, when at Fruholm, in July, 1868, it was from 48° to 50°, but in September only 46° to 48°. It is not improbable that the frequent rain and warm autumn of 1867, and in 1868 the exceedingly warm summer of the middle latitudes, which extended to

Notes.

America and tempered the waters of the Gulf Stream quite early, were the cause of the above two higher temperatures. 34-45.

[34] Température de la Mér entre l'Islande, l'Écosse et la Norvége, avec 5 cartes, par H. Mohn, Directeur de l'Institute Méteorologique de Norvége 16 pp., Christiania, B. M. Bentzen, 1870. (The five charts show the temperatures of the surface of the sea between Norway, Scotland and Iceland in the four seasons, (winter, spring, summer, and autumn,) and for the entire year, from season and annual means, by isothermal lines for every degree Celsius, but they are only rough sketches. Stykkisholmr, for instance, lies not, as shown by Mohn, on the *north* coast of Iceland, but on the *western* coast, in Breithi Fiord or Broad Bay.) 34.

Oversigt over Norges Klimatologi of H. Mohn, Professor, Kristiania, Trykt hos Carl C. Werner et Co., 1870. (Very valuable review of the Norwegian meteorological observations and labors up to 1870, containing air temperature, sea temperature, moisture of air, pressure of air, winds, rain, snow, &c., with many tables.)

[35] Oversigt over Norges Klimatologi of H. Mohn, page 26. 35.

[36] "Zeitschrift für Allgem. Erdkunde, Neue Folge iv," pp. 50 and 503. 36.

[37] "Meyer and Möbius, Fauna der Kieler Bucht, Leipzig, 1865," p. iv *et seq.* 37.

[38] "Zeitschrift für Allgem. Erdkunde," N. F. vi, p. 11. 38.

[39] Letter of Mr. W. von Freeden, director of the North German "Seewarte," dated Hamburg, October 26, 1869. 39.

[40] Manuscript of Dr. E. Löffler, Copenhagen, November 16, 1869, and March 18, 1870. 40.

[41] Manuscript communication of the Montreal Ocean Steamship Company, dated Liverpool, November 26, 1869. 41.

[42] Manuscript of the same, dated Glasgow, December 3, 1869. 42.

[43] Unclear in the manuscript, whether 43° or 50°. 43.

[44] Inglefield. A Summer Search for Sir John Franklin, with a peep into the Polar Basin, 1852. London, 1853, p. 198. 44.

[45] "Zeitschrift für Erdkunde," vol. i, 1853, p. 488; vol. iii, 1854, pp. 43 and 169 *et seq.;* vol. xi, 1861, pp. 191 and 299 *et seq.* 45.

Notes

46-54. [46] Letter of Rear-Admiral C. Irminger, dated Copenhagen, February 4, 1870.

47. [47] "Zeitschrift für Erdkunde," vol. iii, 1854, table 4; vol. xi, 1861, table 2.

48. [48] Letter of Rear-Admiral Irminger, February 4, 1870.

49. [49] We know from the British expedition of Palliser, further from the twenty-seven Norwegian ships, and principally from Johannesen and Carlsen, that in the summer of 1869 there has been very little ice in the eastern part of the European Arctic Ocean, near Nova Zembla, and in the Kara Sea; and from Admiral Irminger's communications it appears that very little, hardly any, was found in the southwestern part of the sea between Iceland and Greenland. It is therefore probable that an uncommon amount of ice remained north of Iceland, and that it would have been well to retain my original plan for the second Polar expedition, viz, to send one of the vessels to East Greenland, and the other east to Nova Zembla.

50. [50] Letter of Dr. G. C. Wallich, dated London, November 25, 1869.

51. [51] Lord Dufferin's letters from high latitudes, being some account of a voyage in the schooner-yacht Foam. London, 1857.

52. [52] Pages 413 to 424 of the same. Lord Dufferin shows the differences between the temperature of the air and that of the sea graphically by a profile.

53. [53] Compare Von Freeden's discourse on the scientific results of the first German North Polar expedition, paper No. ii of this volume, pp. 117 *et seq.*, and note 206.

54. [54] Manuscript letter of Dr. Dorst, dated Jülich, October 26, 1869. Dr. Dorst remarks: "The probable error in the observations, I think, is not over 0°.2 F. The temperature of the air is very low, (33°.04,) and I consider Dove's isothermal curve of 2° R. (36°.5 F.) in this region too high north by about ten degrees of latitude, at least for the year 1869. The temperature appears to culminate from the 19th to the 24th of July, and then to fall slowly. The absolute fluctuation in the month is only 9°.2 F., from the minimum 28° to the maximum of 37°.2, while the daily oscillation rarely exceeds 2°.25 F.; in the mean it is only 1°.33.

"These very small fluctuations probably are caused by the melting ice, and are therefore interesting.

"The temperature of the sea, also, is very low (32°.73) and constant, and appears to culminate from the 20th to the 30th of the month, with 34°.21 and 34°.09. The maximum was 35°.6, the minimum 30°.65; the fluctuation, therefore, amounted to 4°.95. The daily fluctuation was found to be, in the mean, 0°.47. The temperature appears to be highest toward evening.

"The small monthly and daily fluctuations in the temperature of the sea, as well as of the air, prove that we were constantly between melting ice. For that reason the differences between the temperature of the sea and that of the air could not be great, but they would have become more distinct if we had withdrawn from the influence of the melting ice." Notes. 54-56.

How small the difference between the temperature of the sea and that of the air is in that region is also shown by Koldewey's observations in 1868. I compute the monthly mean as follows:

	May.	June.	July.	August.	September.
Temperature of the sea............	41.7	30.6	35.5	34.2	37.7
Temperature of the air	42.1	32.3	36.1	33.7	36.0
Excess of the latter..........	+ 0.4	+ 1.7	+ 0.6	− 0.5	− 1.7

[For an account of Dr. Dorst's expedition, see note No. 125.—HYDROGRAPHIC OFFICE.]

[55] "Geographische Mittheilungen," 1870, number 4, table 8. 55.

[56] Manuscript of Dr. C. F. Frisch, dated Stockholm, February 19, 1870: "Meteorological observations of Captain Baron F. W. von Otter and of Lieutenant L. Palander, during the Swedish Polar expedition, in 1868." Placed before the Royal Academy of Science, in Stockholm, October 13, 1869, by Professor A. E. Nordenskiöld. 56.

[The following is a brief account of this expedition, read before the Royal Geographical Society. (Proceedings, vol. xiii, p. 151 *et seq.*) The results of the expedition, as far as the currents and especially the Gulf Stream are regarded, are discussed in note 115.—HYDROGRAPHIC OFFICE.]

Account of the Swedish North Polar Expedition of 1868, under the command of A. E. Nordenskiöld and Fr. W. von Otter.—Extracts.

The study of the natural history of the Polar regions has been of late years prosecuted in Sweden with so much interest that, exclusive of the present year's undertaking, no less than three* separate expeditions have been sent out from

---

* These were the following:

The Expedition of 1858, fitted out at the expense of Otto Torell. The following gentlemen took part in the undertaking: O. Torell, A. E. Nordenskiöld, A. Qvennerstedt. The expedition visited the western coast of Spitzbergen, and brought home considerable zoölogical and geological collections.

The Expedition of 1861, fitted out at the public expense. The gentlemen who took part in the expedition, besides the proposer and chief, O. Torell, were A. von Göes, A. T. Malmgren, F. A. Smitt, G. von Yhlen, zoölogists and botanists: B. Lilliehöök, and W. Kuglenstjerna, commanders of the vessels; C. W. Blomstrand, C. Chydenius, N. Dunér, and A. E. Nordenskiöld for geological and physical investigations. The expedition visited, in both vessels, the western and northern coasts of Spitzbergen, made extensive journeys in boats for the purpose of constructing a topographical and geological map of the group of islands, and of examining the northern part of the triangulation for degree-measuring, which the present president of the Royal Society, General E. Sabine, as early as 1826, proposed to get executed in these high northern regions; and lastly brought home with them a collection of materials for studying the fauna, flora, and geology of the islands, probably not surpassed in completeness by any similar collections from districts situated at so great a distance from the centers of civilization.

The Expedition of 1864, fitted out at the public expense, chiefly for the purpose of continuing the survey for the measurement of the degree. The gentlemen who took part in the undertaking were A. E. Nordenskiöld, chief, N. Dunér, and A. J. Malmgren. The expedition visited the southern part of Spitzbergen and Storfiord, completed the survey for the degree-measuring, and brought home rich geological, zoölogical, and botanical collections.

Note.

56. (Con'd.) this country to the Arctic seas. When Nordenskiöld, last winter, again brought forward a proposal for a new expedition, on a different plan, which was to set out in the autumn from the northern coast of Spitzbergen and penetrate further northward, the means requisite to defray the expenses of the expedition were, in a few days, raised in the second city of Sweden, Göteborg, (Gottenburg,) at the instance of the resident governor, Count Ehrensvard. When, moreover, the Government, in order to assist the undertaking, fitted out and manned the steamship Sofia, well adapted for the purpose, strongly built of Swedish iron, and originally intended to carry the mails over the Baltic in winter, the new expedition was enabled to assume a more extensive character and embrace a wider compass than had originally been intended.

Most expeditions of this kind have had for their object to attain as high a degree of north latitude as possible; but a glance at their history will convince us how difficult and uncertain the attainment of this object is, and how frequently an insignificant circumstance has obliged the, in other respects, best-planned expeditions to return without any scientific result whatever—a contingency which there would have been no reason to apprehend if proper care had been taken in the scientific furnishing and manning of the expedition. In order to remove all fear of the new Swedish expedition having a result of this kind, it was determined that in this, as in the preceding Swedish Arctic expeditions, a continuation, as general as possible, should be made of the researches in natural history commenced by their predecessors. For this purpose the expedition was, by the Royal Academy of Science in Stockholm, provided with a carefully selected and appropriate scientific apparatus, and was accompanied by as numerous a body of professional scientific men as room and circumstances permitted.

The plan of the journey was, during the summer and early part of the autumn, to pay a visit in the Sofia to Beeren Island and Spitzbergen, and carefully examine both the marine and terrestrial fauna of both lands; their flora, both phanerogamous and cryptogamous, as also their geography and geology. It was also intended to make deep soundings, and to take meteorological and magnetical observations, &c. A supply of coal was to have been deposited by a ship, hired for that especial purpose, at some fitting spot on the northwest corner of Spitzbergen, which is accessible till late in the season; which tract the Sofia was accordingly to visit during the course of the autumn, and whence some of the scientific men were, in the beginning or middle of September, to return in one of the colliers to Norway. The rest were to endeavor, in the Sofia, to make their way further north, and, if necessary, to pass the winter (circumstances permitting) in some appropriate harbor of the Seven Isles, which form the Old World's most northern archipelago.

The gentlemen who took part in the expedition were: Geologist, A. E. Nordenskiöld; Captain, Fr. W. v. Otter, Royal Swedish navy; Lieutenant, A. L. Palander, Royal Swedish navy; Physician, C. Nyström; Natural Philosopher, S. Lemström; Zoölogists, A. E. Holmgren, A. J. Malmgren, F. A. Smitt; Botanists, Sv. Berggren, Th. M. Fries; Geologist, G. Nauckhoff.

The vessel was manned by fourteen seamen, together with zoölogical conservator Svensson, and six dredgers, hired in Norway. The ship placed at the disposal of the expedition having been, under the inspection of Captain von Otter, duly fitted out in Carlscrona, and furnished with provisions for something more than a year, or, when account is duly made of the game that in these parts one may always reckon upon, for about a year and a half, and touched at Göteborg to take on board the scientific apparatus and the men of science who took part in the undertaking, anchor was weighed on the 7th of July. On the 16th Tromsöe was visited, where they remained until the 20th, for the purpose of taking in coal, &c. Note 56. (Con d.)

On the 22d the Sofia cast anchor in the southern harbor of Beeren Island, where some members of the expedition landed to study the natural phenomena of a place difficult of access on account of the want of a good harbor; while the remainder continued on board the vessel, which cruised in the neighborhood, and occupied themselves with soundings and with an examination of the local marine fauna.

The expedition left Beeren Island on the 27th of July. Our course was directed to the eastern coast of Spitzbergen, which had not been visited by any of the previous Swedish expeditions; but at South Cape we met with ice, which, as we approached the Thousand Isles, became more and more abundant, and we were obliged to turn back. After some hesitation as to whether we should wait at South Cape till the water became more free from ice, in order to proceed further eastward, or at once begin the scientific operations on the west coast of Spitzbergen that entered into the plan of the voyage, we embraced the latter alternative; and it was very fortunate that we did so, for on our return home we learned that the east coast, during the whole summer of 1868, had been rendered completely inaccessible by the ice.

Our course was now directed to Ice Fiord, where the Sofia cast anchor on the morning of the 31st of July. We continued a fortnight in the different harbors of that extensive fiord, and penetrated, in our boat excursions, to the innermost parts of the fiord's northern arm, which had not previously been visited by the Swedish expeditions. During this time all the members of the expedition were busily occupied in scientific researches and in collecting objects of natural history. The change was, indeed, advantageous, as well for our zoölogical and botanical as especially for our geological investigations.

The previous Swedish expeditions had pretty fully explored the principal features of the geology of Ice Fiord, and had found it, in consequence of the varying strata on its shores, full of different types both of animal and vegetable remains, and unusually rich in materials illustrative of the geological history of the extreme north.

Innermost in the fiord are found immense, probably Devonian, beds of red clay-slate and sandstone, which, however, do not here contain petrifactions. On them lie strata of limestone, gypsum, and flint, filled with large, coarse-scaled, mountain-limestone brachiopoda; then come Trias-beds, with large nautilus forms and remains of saurians; after these, Jura strata, with ammonites; then Tertiary strata, in many places rich in plant-impressions, indicating a former temperate climate; and lastly, scanty remains of Post-tertiary strata, with plant-fragments and sub-fossil marine shells, *some of which now first occur in living condition in the northern parts of Norway.* The preceding Swedish expeditions had brought home specimens from all these strata; not, however, sufficiently numerous to give a geological representation of the place's former history so complete as the importance of the subject requires. To supply this defect was one of the chief objects of the expedition of 1868; and we succeeded in bringing home unusually rich collections, especially of plant impressions and trias petrifactions, which, when

Note.
56. duly studied, will, no doubt, throw much light on the condition of the climate
(Con'd.) and arrangement of the land of the Arctic regions at that remote period.

Spitzbergen, as is generally known, is at present frequently visited by Norwegian ships engaged in walrus and seal fishing, or in fishing for the "haakjoering" *(Scymnus microcephalus)* on the banks near the island's coast. The walrus is, however, now but very rarely met with on the western side of Spitzbergen, and its fiords are therefore only occasionally visited for the purpose of taking in water or hunting the reindeer. On how large a scale the hunting of these animals may be carried, is evidenced by the circumstance that the vessels fitted out from Tromsöe alone, in 1868, according to official returns, killed 996 head. From Hammerfest the returns are still greater; whence one may conclude that, in spite of the war of extermination which, under the name of hunting, has, for some time, been carried on against these animals, two or three thousand head are annually slaughtered. If we compare that number with the scanty extent of ice-free meadow land in Spitzbergen, we are tempted to suppose that an immigration must take place from Nova Zembla, which, nevertheless, is scarcely possible, unless some large island, or group of islands, facilitate the communication between these two countries, situated at a distance of between 400 and 500 sea miles from each other. Of late years the Norwegians have resumed the method, formerly employed by the Russians, of using large nets, formed of rope, to catch the beluga, *(Delphinopterus leucas;)* and, in 1868, several vessels were fitted out exclusively for that species of fishing. Some of the fishermen whom we met had, on one or two occasions, taken from twelve to twenty head at a single drag of the net; right handsome sport, when one considers that the *Delphinopterus* is often larger than the walrus itself.

Ice Fiord, like most of the other gulfs of Spitzbergen, is surrounded by vast glaciers, with their mouths turned toward the sea, which offer to the geologist an opportunity of studying that important phenomenon in the history of the earth's development. But also extensive valleys or declivities, free from ice and snow, are met with, especially in the inner parts of the fiord, and the fertile soil here produces a vegetation more luxuriant than in other parts of this island group. One may here see whole fields yellow with poppies, *(Papaver medicante,)* or covered with a thick green and red carpet of the beautiful *Saxifraga oppositifolia.* The fiord, which lies beneath them, and in the summer-months is often as still and clear as a looking-glass, abounds with marine animals of various kinds. Everything contributes to make this a most important spot for the study of both animal and vegetable life in the Arctic regions. The zoölogists and botanists of this expedition here gathered a rich harvest, among the results of which we may mention the taking of several fine salmon, and fully-developed examples of the esculent mushroom, &c.

We left Ice Fiord on the 13th of August. At the entrance a boat party was sent out northward, to map and examine geologically Foreland Sound. Their work was now, as during the expedition of 1861, when Blomstrand and Dunér sailed through the sound, rendered difficult by almost perpetual fog. During this time the vessel made a somewhat longer excursion westward, for the purpose of making soundings; which, however, were, on the occasion, rendered almost impossible by the heavy swell. We had arranged to meet at King's Bay, whither both parties came on the 17th, in the afternoon. Several zoölogical, botanical, and geological excursions having been made from this point, and a large number of miocene fossil plants collected, the Sofia, on the 19th, proceeded on her course farther northward. **Note. 56.** (Con'd.)

We had hoped here, in some degree at least, to reinforce our already considerably diminished stock of coal, but we soon found that that would necessarily cause too great a delay. In fact, whereas, more to the south, the tertiary formation occupies the greater part of the extensive peninsula between Ice-Fiord and Bell Sound, and there, in many places, forms mountains of above a thousand feet high, at King's Bay, on the contrary, its extent is very inconsiderable, so that, at present, it forms only a few small hills consisting of strongly-folded strata, and separated from each other by the furrows cut by the glacier-streams. By this the supplies of coal, notwithstanding the by no means inconsiderable thickness of the beds and their accessibility, (they lie only a few hundred feet from the shore of one of the best harbors in Spitzbergen), become of but little value, especially as the frost, which begins at a very short distance under the surface, renders the breaking of them extremely difficult; in fact, in consequence of the ice-drenched coal's extreme toughness, almost impossible without regular mining. It is even to be expected that the whole of what still remains of the miocene formation of this spot will, in a comparatively short period, be washed away.

Late at night, on the 20th August, the Sofia anchored at Amsterdam Island, and the following day we had the pleasure of hailing the first of the ships which had been hired in Norway for the expedition for the transport of coals. A coal depot having been established on the low tongue of land that shoots out southeastward from Amsterdam Island, and five of the scientific members of the expedition having been, together with necessary tents and boats, landed at Kobbe Bay, to prosecute there their zoölogical, botanical, and physiological researches, the Sofia sailed off with the rest on a sounding-tour toward Greenland. Our intention was to penetrate thither along the 80th degree of N. latitude, but before we had reached the longitude of Greenwich we were met by impassable masses of drift-ice. It was evident that the coast of Greenland was accessible only at a latitude much lower than was compatible with the plan of our voyage. We therefore turned our course north and northeast, and gradually, after innumerable zigzags in the ice, arrived at 81° 16′ N. latitude. The temperature had now sunk to 6° C. (42.8 F.) with thick ice, fogs, and snow-storms. The ocean was sometimes covered with a thin coating of new ice, and the old ice northward was quite impassable, so that we were obliged to seek a passage out in a southeasterly direction. After another vain attempt to reach Depot Point, in Brandewijne Bay, the Sofia anchored, on the 29th, in Liebde Bay.

During the passage of the Sofia from Norway to Spitzbergen, its officers, Captain Baron von Otter and Lieutenant Palander, took a number of soundings in the deeper parts with a "Bulldog" apparatus, of the same kind as that constructed at Tromsö, by Torell and Chydenius, for the voyage of 1861, and which was found to be particularly applicable. These soundings were zealously continued during our cruising amid the drift-ice, between 80° and 82°, and gave very interesting results, not only as regards the ocean's depth in the parts visited by us, but also concerning Arctic animal life at the greatest measurable depths. It showed us that Spitzbergen may, in a manner, be looked upon as a continuation of the Scandinavian peninsula, inasmuch as that island-group is not separated from Norway by any very deep channel, (not above 300 fathoms), whereas a

Note.
56. little to the north and west of Spitzbergen there is a depth of 2,000 fathoms and
(Con'd.) more. From these great depths specimens of clay were brought up by the Bulldog apparatus, which, on immediate and close examination, were found to contain not only several microscopic but even larger and tolerably highly organized animal forms, (*e. g.*, several kind of crustacea and annellata). The greatest depth from which any specimen was procured was 2,600 fathoms, and the mass there raised consisted, for the greater part, of white and red *Foraminifera*, in general scarcely so large as a pin's head. It is, moreover, deserving of remark that, during our cruisings amid the ice, we met with and collected not only a number of pieces of drifting wood, but also (as, for example, at 80° 40′ E.) glass balls of the kind used by the Norsemen at their Loffoden fisheries for floats; an additional proof of the already well-established fact* that the Gulf Stream reaches, though in a greatly weakened state, even these tracts.

Liebde Bay had never before been visited by any scientific expedition, and its topography and geology were accordingly entirely unknown. A boat-party, consisting of Malmgren, Nordenskiöld, and Nyström, with three men, were therefore left here, while the ship went to fetch their comrades who had been left at Kobbe Bay. The boat's journey was favored by calm and mild weather and a clear sky, although a high wind, accompanied by snow storms, prevailed out at sea—a circumstance very common at Spitzbergen, and which is said especially to characterize that beautiful and, according to the unanimous testimony of the fishermen, appropriately-named fiord. We were thus enabled, during the few days that our boat-voyage lasted, to map it and ascertain the character of its somewhat uniform geology. Its shores are occupied exclusively by the same red, green, and dark-gray kinds of slate which in Ice-Fiord are covered by mountain-limestone strata, with *Producti*, and in Mount Hecla form the uppermost stratum of the vast series of schists to which the name of that mountain has been applied. But, as yet, no petrifactions had been discovered in these strata. Their age was accordingly somewhat doubtful, and the probable Devonian fish-remains which we now found here are therefore a discovery of great value in the explanation of Spitzbergen's geology. The lower slate-beds contained some vegetable remains, though probably of too indistinct a character to admit of identification.

On the 2d of September, the boat's company and the ship, returning with our comrades from Kobbe Bay, met at a little distance off the promontory that separates Wijde Bay and Liebde Bay. After remaining in that bay a couple of days longer, the Sofia weighed anchor and touched at the now ice-free Cape Depot, in Brandewijne Bay, in order to fetch away the supply of pemmican that (in 1861) had been left there, an iron boat, &c. We thence steered northward, with the intention of passing round Nordostland to Giles' Land. The greatest part of the arm of the sea that lies between the Seven Islands, Cape Platen, and North Cape, which, in 1861, was already, in the middle of August, perfectly free from ice, we now, in the beginning of September, found covered with a firm crust of ice. It was therefore impossible to reach Giles' Land by this route, and we were therefore obliged, after having, for the purpose of botanical and zoölogical researches, remained a short time at Castién's Islands and Parry's Island, which last, being still encompassed by a girdle of land-ice, was approachable only by

* Among the already given proofs of this may be mentioned that Torell, in 1861, at Shoal Point, met with a bean that had come from the Gulf of Mexico, the *Entada gigantilobium.*

walking over the ice, to seek another passage, namely that through Hinlopen Strait. Our course was directed to its southern part. Note. 56. (Con'd.)

Already, before the end of September, some signs of the approach of autumn had been visible, and the hill-tops had frequently in the morning been, for some time, covered with a white mantle of new-fallen snow, which, however, had melted away again without causing any hinderance to our scientific pursuits. But now, during our passage to South Waijgats Islands, a copious fall of snow rendered all further researches in natural history on land impossible, and gave us clearly to understand that the season for our purely scientific pursuits was to be considered as at an end. We accordingly turned back at Mount Lovén, in the southern part of Hinlopen Strait, having first on that spot collected, from under snow of a foot deep, an additional number of mountain-limestone petrifactions. On the 12th of September we again anchored at our coal depot on Amsterdam Island, and there met our second coal-ship, by which some of the members of the expedition (Fries, Holmgren, Malmgren, Nauckhoff, and Smitt) returned to Norway, carrying with them the valuable collections of objects of natural history which the expedition had, up to that time, succeeded in acquiring. These collections have now happily arrived in Stockholm, and will, after having been duly studied, be divided between the National Museum in that city, where already the extraordinarily rich Arctic collections formed by the preceding Swedish expeditions are preserved, and the Museum of Göteborg, the city whose liberal initiative first gave occasion to the new expedition. To give an idea of the extent of these collections, I need only refer to the notices above given of our geological operations, and remark that the zoölogical sciences were represented by no less than three members of the expedition, who, besides, had with them a taxidermist. Messrs. Malmgren and Smitt had also at their disposal a boat, manned with four men, for dredging every day, holidays excepted, when the ship lay still. They were thus enabled not only to make a searching examination of the Arctic marine fauna, which, in individual copiousness at least, is comparable with that of many more southern countries, but also to pay due attention to the terrestrial fauna of the locality, more especially the entomological branch, which is poor, both with respect to individuals and species, and accordingly presented especial difficulties to its investigator, Mr. Holmgren. The dredgings also yielded rich contributions to the ocean's alga-flora. Every opportunity that offered itself for land-excursions was used by the two botanists of the expedition, both for investigating the flora and for forming a collection of specimens for normal herbaria of Spitzbergen's phanerogamia, mosses, lichens, and algæ.

On the 16th of September we took leave of our homeward-bound companions, and immediately proceeded northward. Our intention was to touch at the Seven Isles, but these were now found to be still more thickly surrounded by ice than when we had visited that tract about a fortnight before. We accordingly determined to avail ourselves of a channel tolerably free from ice, stretching northward from those islands.

After a number of zigzags amid the drift-ice, our vessel, in longitude 17½° E. from Greenwich, succeeded in arriving at 81° 42′ N. latitude, probably the highest northern latitude a ship has ever yet attained. Northward lay vast ice-masses, it is true as yet broken, but still so closely packed that not even a boat could pass forward, and we were therefore obliged to turn to the southwest and

Note.
56. seek for another opening in the ice; but we found, on the contrary, that the
(Con'd.) limit of the ice stretched itself more and more to the south the more we went to the west, so that, on the 23d September, in the longitude of Greenwich, we were south of the parallel of 79° N. latitude. On the way we had, in several places, met with ice black with stones, gravel, and earth, which would seem to indicate the existence of land still farther north.

The ice itself had, moreover, a very different appearance from that which we had met in these tracts at the end of August. It consisted now not only of larger ice-fields, but also of huge ice-blocks, so that it seems as if the former ice had drifted to the south, and given place to new ice-masses coming from the north. The temperature had now sunk to 8° or 9° (C.) below the freezing point, (21.2 or 17.6 F.) and the ice, which in these parts had before been of tolerably loose texture, had now become so compact that any more violent collision with it was combined with no little danger. Furthermore, the nights were now so dark that it was necessary at that time to lay the ship to by the side of some large sheet of ice, at the hazard of finding one's self blocked up there in the morning. Already, in the beginning of September, the surface of the ocean, after a somewhat heavy fall of snow, had shown itself, between the ice-masses, covered with a coating of ice, which, however, was then thin, and scarcely hindered the vessel's progress. Now it was so thick that it was not without difficulty that a way could be forced through it. All things clearly indicated that the season of the year, during which it is possible to sail in these tracts, was nearly at an end, and as we intended to make yet another attempt to find a north passage from the Seven Isles, or seek a harbor for the winter, we determined to return to our coal-depot.

On the 25th of September the Sofia once more cast anchor at the northwest corner of Spitzbergen, after having slightly struck upon a rock situated under the surface of the water in the middle of South-gat, and which has been forgotten in Buchan and Franklin's admirable chart of that harbor, although it appears, from Beechy's description, that they themselves happened to strike on the same shallow.

After a few days' rest, spent in inspecting the engine and taking in coal, (the last remains of our store of coals had to be searched for under a thick covering of snow,) and after having placed in the letter-box on the island in Kobbe Bay notices of our journey and our plans for the future, we steamed away again, on the 1st of October, northward, nothwithstanding a strong wind and a snow-fog that prevailed in the harbor we left. Our suspicion that this was only local seemed to be confirmed when we got out a little farther north, as the weather became clearer and calmer, but at the same time we met already, in latitude 80° 40′, sporadic blocks of drift-ice, which, as we proceeded further north, increased in number and size. We continued our northward course during the following day, but it was soon evident that no open water would be arrived at that way, and in the afternoon we were again steering in a southerly direction. During the night we lay to under cover of a large sheet of ice. The temperature had now sunk to 14°.5 C., (5.9 F.), so that in calm weather the surface of the water between the ice-masses was covered with ice of two or three inches thickness, which considerably impeded the progress of the ship. But the following day we stood southward till we got into something like open water, and then followed the edge of the ice in a northerly and northwesterly direction. By this means we again arrived at 81° N. latitude, but here the Sofia met with a misfortune, which put an end to all further efforts to proceed northward. In the morning of the 4th of October, during a storm from the southeast, and with a high sea, the ship was thrown violently upon a huge ice-block, or rather a small iceberg, whereby she sprang an extensive leak. We were therefore forced to turn back immediately and seek our harbor, where we arrived late in the evening, after eleven hours of incessant labor to keep the vessel free from water. Nevertheless, though all took part in this work, the water continually rose, so that, when the anchor was cast at Amsterdam Island, it stood about 2 feet over the cabin floor. Fortunately the provisions, being kept between water-tight bulk heads, were uninjured, and we succeeded, though with great difficulty, in keeping the engine-room so free from water that the fires were not extinguished. Had this not been the case, our ship must unquestionably, in a short time, have been the prey of the storm and the extremely heavy sea, which now, contrary to our former experience, raged among the thinly scattered fields of drift-ice. Immediately on our arrival at Amsterdam Island the ship was careened and the leak provisionally stopped, so that already the next day we were in a condition to seek a more secure harbor in King's Bay. Here the ship was hauled so close to land at flood that we, at ebb, were enabled to come at the leak and stop it effectually.

Note. 56. (Con'd.)

King's Bay, which in summer-time is almost free from ice, was now filled with innumerable ice-blocks fallen from the mighty glaciers of the fiord, which, when carried by the flood tide in toward land, totally barricaded the harbor in which the Sofia had taken refuge; and, notwithstanding that the temperature here was considerably higher than in the neighborhood of 81° N. latitude, these blocks froze during the calm weather so fast together that when we, on the 12th of October, were again in a condition to sail, it was only with the utmost difficulty that our vessel could get out.

Our stay in King's Bay, like all the preceding occasions on which the ship remained any length of time still, was taken advantage of by our natural philosopher, Dr. Lemström, for the purpose of making observations for the determination of the magnetic constants and variations. The ground was, however, too deeply covered with snow to allow of any geological or botanical operations. Even the brooks, so copiously supplied with water in the summer time, which intersect the lowlands adjoining the coal harbor, were now so entirely dried up by the effect of the cold that we endeavored in vain to reinforce our now considerably reduced supply of water.

Our ship, which had had two ribs broken by the blow that caused the leak, was now too weak to be exposed, with the slightest prospect of success, in any new attempt to force a way through fields of drift-ice, as would in all probability be necessary, should we endeavor to visit the Seven Islands, which place we had intended to make our winter harbor; and the wintering in any other part of Spitzbergen not having either entered into the plan of our voyage, nor promising any results commensurable with the costs, dangers, and hardships of passing the winter there, we determined to return to Norway. But yet we wished to make an attempt to reach Giles' Land round the southern point of Spitzbergen, which was probably still free from ice. Already during our passage along the west coast of Spitzbergen, which in summer is entirely free from ice, we passed large though scattered fields of ice, which farther to the east, near the Thousand Isles,

Note.
56. completely obstructed the way. We were, therefore, constrained to relinquish
(Con'd.) that plan also, and to direct our course toward Norway. After having been once more on the shallow banks off Beeren Island, during a severe storm and in a high sea rendered to the last degree boisterous by the shallowness of the water, in great danger of being ice-beset, the Sofia anchored again on the 20th of October in Tromsö Harbor, where we had the pleasure of learning that our comrades had happily arrived and reached home in safety.

From the above it appears that the expedition, as regards its second object—namely, hydrographical investigations in the Polar basin—did not succeed in reaching any remarkably high degree of latitude; so that the compass of the portion of our globe that is known to us has not been to any material amount increased by it. I hope, however, that it has afforded a by no means unimportant contribution to the solution of the so-called Polar question.

A lively controversy has, as is generally known, been of late years carried on between the principal geographical authorities concerning the real character of the polar basin, some geographers maintaining that it is covered by an unbroken surface of ice, presenting an impassable barrier to the progress of a ship; while others look upon this as only an obsolete prejudice, arising in a great measure from exaggerated descriptions of the difficulties which the sailor encountered at the point where he turned back. That this latter view, at least as regards that portion of the Polar basin that borders on Europe during the actual sailing season in the Northern Seas, *i. e.*, the summer, is not in conformity with the real fact, has been proved, not only by the adventurous journeys of the older Arctic travelers, but by a number of expeditions sent out during the last century for the exclusive purpose of such investigations, among which may be mentioned:

Tschitschagoff's first expedition,	1765,	which with their ship could only reach			80° 21′	N. latitude.
Tschitschagoff's second expedition,	1766,	do.	do.	reached to	80° 28′	N. latitude.
Phipps's expedition,	1773,	do.	do.	do.	80° 37′	N. latitude.
Buchan and Franklin's expedition,	1818,	do.	do.	do.	80° 34′	N. latitude.
Scoresby's expedition,	1806,	do.	do.	do.	81° 30′	N. latitude.
Sabine and Clavering's expedition,	1823,	do.	do.	do.	80° 20′	N. latitude.
Parry's expedition,	1827,	do.	do.	do.	81° 6′*	N. latitude.
Törell's expedition,	1861,	do.	do.	do.	80° 30′†	N. latitude.

It might then have been considered as already absolutely decided that it was not possible at that season of the year to penetrate very far into the Polar basin, and any repetition *at the above-named season of the year* of these attempts could therefore only be looked upon as continually treading in old footsteps, which demonstrably do not lead to the intended object. But one doubt remained. At the season of the year when, in consequence of the heat of the summer and the influence of the ocean-waves and ocean-streams, the ice-masses have been reduced to their minimum—that is to say, in the autumn, before the formation of the new ice, no ship had ever before visited the Polar basin. One could with certainty foresee that it might then be possible to go farther than in summer. There was a possibility that one might at that season be able to penetrate very far, perhaps to some land lying north of Spitzbergen, which might hereafter serve as base from whence to push still further onward. These considerations

* By ship, but on the ice the party penetrated to 82° 45′.
† By ship, but in boats and by land journeys as far as 80° 45′.

constituted the ground for the plan of operations for the latter portion of the Swedish expedition, and it may now be considered as proved. 56-62.

That one may, during autumn, reach by ship a latitude considerably higher than that which has been attained by most of the summer expeditions, unless this year is to be considered as unusually unfavorable with regard to the condition of the ice, we might in all probability have proceeded a considerable distance farther, perhaps beyond 83° N. latitude. But we have at the same time convinced ourselves that, even in autumn, further progress is soon rendered impossible by impenetrable masses of broken ice. The voyage itself, moreover, at that season of the year, in consequence of the cold, the darkness, and the boisterous winds, accompanied by snow-storms that at that time of the year are prevalent in the Polar basin, and the heavy sea amid the masses of drift-ice caused by these latter, is rendered so dangerous that the risk to which the traveler exposes himself is far from being compensated by the meager prospect of success. The idea itself of an open Polar sea is evidently amere hy pothesis, destitude of all foundation in the experience which has already by very considerable sacrifices been gained; and the only way to approach the Pole, which can be attempted with any probability of succeeding, is that proposed by the most celebrated Arctic authorities of England, viz, that of—after having passed the winter at the Seven Islands, or at Smith Sound—continuing the journey toward the north on sledges in the spring.

[57] "Kongl. Vetenskaps-Academiens Handlingar," (transactions of the Swedish Royal Academy of Sciences,) 1869, No. 11. 57.

[58] Manuscript of Dr. Bessels, October, 1869. 58.

[For an account of Dr. Bessel's expedition see his two letters to Dr. Petermann, in note 125. —HYDROGRAPHIC OFFICE.]

[59] Middendorf, Sibirische Reise, (Siberian voyage,) iv, i, 3d number, p. 507. 59.

[60] Voyage des découvertes de la corvette L'Astrolabe, éxecuté pendant les anneés 1826–1829, sous le commendement de M. Jules Dumont D'Urville. Observations de physique, pp. 69 *et seq.* Paris, 1834. 60.

[61] Mémoire sur les températures de la Mér Glaciale, à la surface, à des grandes profondeurs, et dans le voisinage de glaciers de Spitzberg. Par Ch. Martins, member de la Commission scientifique du Nord. Paris, 1848. 61.

[62] Manuscript of the Royal Commission on the Irish oyster-fisheries, dated Dublin, December 3, 1869. All the observations were made at noon, on the oyster beds near the coast, when such were found, else in shallow water near the coast, one foot below the surface. At sea, generally half a mile from the shore, at depths of not less than three fathoms, the thermometer was lowered six feet below the surface. 62.

Notes.

63-67. [63] The distance between the points of observation on the coast and at sea varied from nine feet to one nautical mile; the depth of the water, according to the state of tide, between 2 feet and 6 fathoms.

64. [64] The distance of the various stations of observing at sea from the shore was 1 to 4½ nautical miles; the depth of water, according to the state of tide, from 6 to 12 fathoms.

65. [65] The depth of the water varied, according to the state of tide, from 2 to 8 feet.

66. [66] A. M. J. van Asperen, Directeur der Afdeeling Zeevaart, Berigt over 1863. Utrecht, Maart 1864.

67. [67] Geographische Mittheilungen, 1862, pp. 431 and 432. The following is the notice referred to, originally from an article in the Nautical Magazine: "On the proper depths for electric cables as at present constructed." Captain T. Spratt, known for his extensive surveys and soundings in the Black and in the Mediterranean Seas, publishes in the Nautical Magazine (1862, p. 1 *et seq.*) his views as to the depths best suited for telegraphic cables, and especially the influence of the pressure and of the temperature on the gutta-percha arming. Incidental to this he makes the following statement in regard to the temperature of the Mediterranean Sea at various depths:

"The Mediterranean temperatures are known to be not very low at great depths, but reach their minimum as a permanency in from 100 to 300 fathoms; and this minimum temperature seems to correspond with the average annual temperature of the locality itself. And as the Mediterranean is divided into a series of basins, with comparatively intermediate shallows, it is its surface-waters, about the depth of 200 to 300 fathoms, (being that of the barriers which separate them,) that unite by their superficial and encircling currents. Thus, as the depth across the Strait of Gibraltar is under 200 fathoms, the very cold waters in the depths of the Atlantic or of the Black Sea do not intermingle and exert their individual temperature in the depths of the central basins. The temperature of the deeper waters of the Mediterranean, Archipelago, Sea of Marmora, and Black Sea are consequently each dependent on local influences, namely, from the solar or atmospheric temperature above them. Therefore the minimum temperatures of their deeper parts correspond nearly with the mean annual temperature over them.

"The following are some of the temperatures taken by me in various parts of the Mediterranean:

Grecian Archipelago, July 25.

Air	86°
Surface	78°
10 fathoms	74°
20 fathoms	74°
60 fathoms	64°
90 fathoms	64°
120 fathoms	56°

Off Crete, September 20, 1852.

Air	76°
Surface	75°
10 fathoms	72°
50 fathoms	59°
120 fathoms	56°

Note. 67. (Con'd.)

Between Malta and Tripoli, May, 1861.

Surface	62°
Bottom, in 295 fathoms	62°

Off the coast of Egypt, in April.

Surface	63°
20 fathoms	61½°
270 fathoms	59½°

Off the coast of Egypt, November 15, 1861.

Surface	73°
30 fathoms	71°
50 fathoms	68°
80 fathoms	64°
100 fathoms	62½°

In the Gulf of Syrtis, February 21, 1861.

Surface	61°
20 fathoms	62°
50 fathoms	62°
290 fathoms	62° ?

Gulf of Syrtis, February 27.

Air	56°
Surface	60°
50 fathoms	61°
100 fathoms	61½°

Off Arab Gulf, west of Alexandria, April 6.

Air	68°
Surface	62°
20 fathoms	61½°
300 fathoms on bottom	59½°
Another thermometer, a simple minimum, at 1 fathom above bottom	58¾°

Off Crete, June 14, 1860.

Air	80°
Surface	73°
10 fathoms	68°
20 fathoms	68°
30 fathoms	68°
50 fathoms	63°
100 fathoms	59¾°
200 fathoms	59¾°
1240 fathoms	59½°

Off east end of Rhodes, August 25, 1860.—Barometer, 29.88; hydrometer, 74°.

Air	88°
Surface	82°
10 fathoms	81°
20 fathoms	79½°
30 fathoms	78½°
50 fathoms	77°
100 fathoms	73°

In 300 fathoms water, but the lower temperatures were not obtained for the lower depths.

"In the Grecian Archipelago I long since showed it to be constant at about 54° or 55° in depths from 100 fathoms and downward. In that sea the temperature of the intermediate depths between 100 fathoms and the surface, in the summer season, ranges from 55° to 76°, and indeed even up to 80°, and 86° sometimes in the littoral waters of inclosed gulfs and shallow bays.

"In the eastern and western basins of the Mediterranean it will have, consequently, a higher minimum temperature than that; and I find that it is about 59° in all depths from 300 down to 2,000 fathoms. But between 300 and the depths of 30 fathoms there is an increasing variation from that temperature to 73° and to 75° in the summer months, but confined more particularly to the depths between 80 and 100 fathoms and the surface. But in the winter months of December, January, February, and March the upper depth is nearly at the minimum temperature of the deepest parts below, namely from 59° to 62°, varying with the locality and depths of water there. Thus it is that in these months the surface and deep waters of the Mediterranean are at a constant temperature of about 10° or 15° above that of the atmosphere. After the month of March, however, the solar influence begins sensibly to raise both sea and atmospheric temperature, so that in July, in the southern part of the Mediterranean, it is at its maximum of about 75°, from the surface down to the depth of about 30 fathoms below it."

Notes.

68-75. [68] H. W. Dove, "Temperatur Tafeln," Berlin, 1848. H. W. Dove, "Klimatologische Beiträge," part 2d, Berlin, 1869.

69. [69] St. Petersburg calendar for 1869. Smitzdorf, St. Petersburg, pp. 62 *et seq.* A compilation "revised and completed from the journals of the principal physical observatory." The author says:

"To avoid the precarious confrontation of observations extending over very different periods, I have adopted for the greater part of the Russian empire the means of the observations for the years from 1838 to 1867. This period of thirty years is sufficient for a pretty accurate mean value. Where the observations do not embrace that period, I included the observations obtained for the time yet required at the three or four nearest stations after correcting them for the distance between the stations. In that way I have been able to obtain for the greater part of European Russia, for Siberia and Transkaukasia far surer results than the previous tables for the Russian climate give. So, for instance, is in the latter the annual mean temperature of Baku recorded to be higher by 1°.1 than that of Lenkoran. By comparing the observations of an equal period this anomaly will be removed, as will be seen from my table, where, on the contrary, the temperature of Lenkoran is shown to be higher by 0°.45 than that of Baku; this difference increases in some months to more than 2°.

"For West European Russia, where the observations date back to a far earlier time than in the other parts of the empire, I have thought it judicious to take a larger period. For instance, for Petersburg I have made use of the observations during 79 years; for Warshar of 61 years," &c.

70. [70] Nine hundred and fifty Swedish feet above the level of the sea.

71. [71] Letter of Dr. J. Hann, dated Vienna, September 18, 1869.

72. [72] Schmid "Lehrbuch der Meteorologie;" p. 244.

73. [73] The same, p. 246.

74. [74] The same, p. 247.

75. [75] "Geographische Mittheilungen," 1862, p. 359.

[The notice referred to is from: "Meteorologische Beobachttungen auf dem Atlantischen und Grossen Oceane in den Jahren, 1847 und 1849, von Dr. Lenz. (Bulletin de l'Académie Impériale des Sciences de St. Pétersbourg, V., No. 3, pp. 129 to 155.)

Dr. Lenz publishes the observations of his nephew on board of the Russian ship Achta, from which he had already published in 1860 the interesting result, that on the ocean in the tropics the maximum temperature occurs half an hour before noon. He now deduces some other results. The mean temperature of the equatorial belt from 10° N. to 10° S., for instance, is found to be for the Atlantic Ocean 78°.73, and for the Pacific Ocean 78°.5. The observations of the temperature of the water in 60 fathoms confirm that there is in the region of the calms a considerably quicker decrease of the temperature with the increase in depth than anywhere else in the tropical or sub-tropical zones.—HYDROGRAPHIC OFFICE.]

Notes.

[76] "Geographische Mittheilungen," 1865, p. 156. Jukes (Excursion in and about Newfoundland, 1839; London, 1842, i, p. 312) states that walruses and polar bears come to Newfoundland by the drift ice, and are hunted there, in the same latitude as Mayence, Paris, Cherbourg, and Brest. Never has a single one of these animals been cast on the coasts of France or Great Britain, and only once (in 1851) has a polar bear, and but once (in 1816) a walrus been seen on the northern coast of Norway, although they abound in the vicinity of Norway, Spitzbergen, Greenland, Nova Zembla, and even on Bear Island, which is distant from the North Cape only 240 miles. 76-89.

[77] "Geographische Mittheilungen," 1867, p. 184, *et seq.* 77.

[The passages referred to are translated in full in note 4, page 198 of this volume.—HYDROGRAPHIC OFFICE.]

[78] Map showing the soundings in the North Atlantic Ocean taken on board H. M. ship Bulldog in 1860, and Wallich, the North Atlantic sea bed, London, 1862. 78.

[79] Wallich, p. 145. 79.

[80] Scoresby, Voyage to the Northern Whale Fishery in 1823, Edinburgh, 1823, pp. 14, *et seq.* 80.

[81] Buchan, Handy Book of Meteorology, Edinburgh, 1868, p. 136. 81.

[82] Purdy, Memoir of the Northern Ocean, London, 1850, p. 3. 82.

[83] Carl Vogt, "Dr. Berna's Nordfahrt," p. 317. 83.

[84] McClintock's Bulldog Expedition, 1860. Proceedings R. Geog. S., v, p. 62. 84.

[85] Mühry, "Klimatologische Uebersicht der Erde," p. 571. 85.

[86] Göppert, "Beiträge zur fossilen und lebenden Flora." (Contributions to the fossil and living flora.) Separate publication from "Verhandelungen der Schlesischen Gesellschaft für vaterländische Kultur vom Jahre, 1860," pp. 7 and 8. 86.

[87] Carl Vogt, "Dr. Berna's Nordfahrt," p. 254. 87.

[88] Globus, 1870, vol. xvii, No. 8, p. 127. 88.

[89] Bulletin of the Museum of comparative zoölogy at Harvard College, Cambridge, Massachusetts, Nos. 6 and 7. Contributions to the Fauna of the Gulf Stream at great depths, by L. F. de Pourtales, p. 142. 89.

Notes.
90-95. [90] "Geographische Mittheilungen," 1867, p. 115, where the following is found from a memoir of Ssidoroff in the "Russian Westnik," vol. 63, p. 116, May, 1866: "A merchant vessel, freighted with codfish, under Captain Kononoff, sailed in the summer of 1864 from Kola, in Lapland, to St. Petersburg. On returning she left Cronstadt October 6th, and Copenhagen, her last harbor, November 1st. In the middle of that month she passed North Cape at the distance of 50 Russian versts, (about 29 nautical miles,) then Wardöhus at 60 miles distance, and entered the Teriberka November 18th, finding there a temperature of —18°, and hardly any daylight. On the 5th of December she arrived at Kola." There is nothing said of ice in this report.

91. [91] Manuscript memoir on Russian Lapland, by Professor J. A. Fries, of Christiania.

92. [92] "Geographische Mittheilungen," 1865, p. 156.

[A more full account of the ice in the Baltic, the Azof, and other seas, will be found in the "Geographische Mittheilungen" for 1855, pp. 54, *et seq.*—HYDROGRAPHIC OFFICE.]

93. [93] "Geographische Mittheilungen." Supplement No. 21.

[This supplement is a monograph by J. Spörer: "Nova Zembla, its geography and natural history." On page 70 of it the following table will be found:

Means of the temperature on Nova Zembla, in Fahrenheit scale.

	Shoal Bay, lat. 73°57′ N.		West end of Matotschkin Shart, latitude 73° 19′ N.	Kamenka Bay on the Karian Straits, latitude 70° 37′ N.
	As observed.	After allowing for the cover of the hut.		
	°			
January	10.4	9.5	4.3	— 2.9
February	5.1	4.2	— 7.7	0.1
March	4.1	3.2	4.5	— 10.7
April	5.5	4.7	8.3	3.1
May	30.5	30.0	19.7	17.5
June	38.0	37.6	34.6	32.9
July	41.5	41.0	39.9	36.3
August	39.4	39.0	41.0	37.5
September	31.7	31.2	31.1	30.0
October	23.3	22.7	22.3	20.3
November	1.0	0.2	8.7	3.2
December	4.3	3.4	— 3.3	12.5
December to February	6.6	5.7	— 2.3	3.2
March to May	13.4	12.6	10.7	3.2
June to August	39.6	39.2	38.5	35.6
September to November	18.7	18.0	20.7	17.9
Means of the year	19.6	18.9	16.9	15.0

94. [94] Baër in Berghaus Annalen der Erdkunde, 1838, vol. v, p. 324.

95. [95] Baër in "Bulletin scientifique de l'Academie de St. Petersburg," vii, p. 235.

[96] From June 1 to June 19, and from August 6 to 31. **Notes. 96-107.**

[97] Compare "Geographische Mittheilungen," 1870, chart, table 8. **97.**

[98] These statements in regard to the climate of Bear Island are from a report of the Arctic expedition of Barto von Löwenigh in 1827. (Compare chapter 6, p. 40, of the supplement No. 16 to the "Geographische Mittheilungen:" "Spitzbergen and the Arctic central region," by Dr. Petermann.) For a short account of this expedition see note 126. **98.**

[99] "Geographische Mittheilungen," 1868, p. 223. **99.**

[The Sabine-Clavering expedition had for its main object observations with the pendulum. The expedition left the Thames May 11, 1823, in the gun-brig Griper, observed at Hammerfest, in the north of Norway, from June 2 to 23; at the N. W. coast of Spitzbergen in 79° 49′ 58″ N., 11° 40′ 30″ E., from July 1 to 24, (during which time Captain Clavering made an attempt in the ship to penetrate north, reaching latitude 80° 20′ N.;) and on Sabine Island, near the east coast of Greenland, in 74° 32′ 19″ N., 18° 50′ W., from August 13 to 31. Returning by the way of Drontheim the ship came to anchor again in the Thames on December 19, 1823. The narrative of this expedition, "Journal of a voyage to Spitzbergen and the east coast of Greenland in His Majesty's ship Griper, by Douglas Charles Clavering, esq., F. R. S., commander; communicated by James Smith, esq., F. R. S. E., with a chart," was published in a magazine of limited circulation, the Edinburgh New Philosophical Journal, April to June, 1830, pp. 1 to 30. Extracts from it are republished in the "Geographische Mittheilungen" for 1870, p. 320, *et seq.* The narrative is very interesting, but contains but little in regard to currents.—HYDROGRAPHIC OFFICE.]

[100] The Swedish expeditions to Spitzbergen; Jena, Costenoble, p. 258. **100.**

[101] Parry, Attempt to reach the North Pole, p. 158. **101.**

[102] The Swedish expeditions, &c., p. 353. **102.**

[103] The same, pp. 128, 241, 247, 303, 353 to 356, 426, 452, 460. **103.**

[104] The same, p. 432. **104.**

[105] The same, pp. 46 and 47. **105.**

[106] The same, pp. 484 and 485. **106.**

[107] "Geographische Mittheilungen," 1868, p. 219. Narrative of an expedition to the east coast of Greenland, sent by the order of the King of Denmark, in search of the lost colonies, under the command of Captain W. A. Graah, of the Danish royal navy, knight, &c. London, 1837, p. 113. **107.**

[As copies of the narrative of Captain Graah's expedition, the original Danish publication as well as the English translation, are said to be now very rare, the summary of it, published by Dr. Petermann in the "Geographische Mittheilungen" for 1868, is here added.—HYDROGRAPHIC OFFICE.]

Note. 107. (Con'd.) The Danish government, to promote the very imperfect knowledge of the east coast of Greenland, sent there, in 1828, a scientific expedition under command of Captain W. A. Graah, who did not return before 1831.

In order not to fail from the same reason that previous expeditions had, Captain Graah did not attempt to reach the coast directly, but proceeded first to the Danish colonies on the west coast, where he procured from the natives two "umiaks," or women-boats, 38 feet long, 7 feet in width, and 2½ feet deep, which he manned with 4 Danes and 15 natives, 10 of whom were women. The expedition left Nennortalik, on the southwest coast, March 21, 1829, and reached the east coast April 1, but could not, on account of the ice, proceed north before the 26th of April.

Graah, not familiar with his very fragile boats and the habits of the native crew, made at first but slow progress, the more slow as the Esquimaux left him one by one, until only two men and six women remained. Think of an expedition of one European naval officer, with two men and six women, pushing along into the Arctic; to the left an unknown coast, rent by numerous incisions and bordered with precipices of 1,000 feet in height, from which a hundred times a day immense glaciers broke loose and dashed into the sea with roars like thunder; and to the right the drift-ice of the ocean! One day one of the women gave birth to a boy, who was placed in a corner of the boat, while the mother took to her oar again.

It took from April 26 to June 23 to go from latitude 60° to latitude 61° 47′; but then, after the greater part of the crew had left, one boat was necessarily abandoned, and better progress made with that remaining.

From the 27th of June to the 22d of July the distance from latitude 61° 55′ to Vendom Island (Return Island) was accomplished—not less than 310 nautical miles in 3½ weeks. Subsequently Graah visited the more northern island, which he named Danebrog Island, (65° 15′ 36″ N.,) the northernmost point reached by him.

The state of his nutshell of a boat, of his female crew, and of his provisions, as well as his intention to explore the indentations (fiords) of the coast discovered by him, prompted him to return to Nubarbik (in latitude 63° 20′ N.) for the winter. After having finished his surveys, he went there to winter October 1, 1829, and left it April 5, 1830, for the south. Although the sea was, at that time navigable toward the north, he did not deem it advisable to venture, with his fragile boat and the female crew, during the spring gales, the exploration of the sea further northward; he continued his surveys between latitudes 63° 20′ and 60° N., and then returned to Friedrichsthal, where he arrived October 15, 1830.

What now did Graah find on this coast, which heretofore was pronounced inaccessible and not habitable?

Everywhere he found open water enough to push through even with his fragile boat. As early as May 23, the open channel had a width of one to two miles; there were now and then accumulations of ice, but he could work through every one. In the northernmost part reached by him, in latitude 65°, the open sea had, toward the end of August, extended to a width which would have allowed very comfortable sailing and long tacks. There also, on Sneedorf Island, he found vegetation more advanced than anywhere lower south.

In his winter quarters on the small island Nubarbik (latitude 63° 20′ N.,) there was also a comparatively luxuriant vegetation. These winter quarters cannot be compared, in the remotest degree, with those of the English expeditions among the confused mass of islands and on the coasts of the American side. On the 29th of October he had still rain, and very mild weather to the end of February, when it became colder, but the lowest temperatures were —6° and —4°. In November and December there were a few days of +14° and +9°.5. In February and March the sea was free of ice to a distance of 12 to 15 miles from the coast. **Notes. 107-8.**

A still better criterion for the climate of East Greenland is afforded by the inhabitants of it and their relations of life.

Graah found the population growing more dense toward the north, instead of getting less. He met—

At two points, between latitudes 60° and 61° N., 32 natives;
At two points, between latitudes 61° and 62° N., 70 natives;
At three points, between latitudes 62° and 63° N., 31 natives;
At four points, between latitudes 63° and 64° N., 223 natives;
At two points, between latitudes 64° and 65° N., 180 natives.

These are comparatively very considerable figures for the generally but very thinly distributed Esquimaux population in the Arctic regions. The entire tribe living on the west coast of Greenland, between Melville Bay and Smith Sound, in an area extending over three degrees of latitude, known by their frequent contacts with Kane and Hayes, counted, when last visited by Dr. Hayes, in 1860–'61, to the utmost only 100 head.

The relations, also, of the necessities of Esquimaux life appear to be more favorable in East Greenland. Graah found, August 30, while penetrating into the inner parts of Ekallumint Fiord, or "Queen Mary's Valley," not less than from 200 to 250 Esquimaux assembled, celebrating a jovial feast, having caught an immense quantity of delicious mountain-trout *(Salmo alpinus)* of considerable size. This feast lasted for days and nights, with illumination and dancing in the latter. Queen Mary's Valley lies in latitude 63° 30′ N., about on the parallel of Drontheim.

Graah describes the Esquimaux of East Greenland as a better and higher race, in all respects, than those of West Greenland; of large stature and stoutly built; the women of good forms and with agreeable features, among them even beauties; in their character throughout most harmless, good-natured, honest, and virtuous people.

At the northernmost coasts and islands visited by him he found the same human figures, carved in wood, which have been found frequently, since Behring's time, among the tribes of Northwest America. This is one of the many reasons that I believe Greenland to extend across the Arctic central region to Behring's Straits (Long's Land.)

108 "Geographische Mittheilungen," 1870, iv, table 8. **108.**

[Chart showing the track and the deep-sea soundings of the Swedish expedition, under Nordenskiöld and von Otter, 20th July to 19th October, 1868, by Dr. Petermann. For an account of the expedition see note 56; and for a review of the results of the expedition note 115.—HYDROGRAPHIC OFFICE.]

Notes.

109-12. [109] "Geographische Mittheilungen," 1869, p. 204, and 1868, p. 369.

[The first citation refers to the "Table of currents observed by the first German North Polar expedition;" (compare note 201;) and the other is a letter of Captain Koldewey, dated July 19, 1868, in 80° 38′ N., 5° 34′ E. of Greenwich, the following passage of which is referred to.—HYDROGRAPHIC OFFICE.]

On the morning of July 4 the weather cleared, with a fresh N. E. breeze, and at noon I could observe for position in latitude 76° 03′ N., longitude 18° 07′ E. of Greenwich. According to the dead reckoning, we should have been to the north of that, and there must, therefore, be a southern current here. As the ice which we saw to the east appeared to be pretty loose, we steered into it, trying to make as much northing as possible. Repeatedly we had to press the ship through quite dense drift-ice, from which she received some hard knocks.

We pushed ahead in that manner for two days, when we should have been, according to reckoning, in 76° 20′ N., 25° E.; the observations, however, showed our positions to be 75° 38′ N., 23° 37′ E. *So strong a current to the S. W. I had not expected.* The ice was now thickening in the north and in the east so considerably that it appeared to me impossible to penetrate farther in this direction.

110. [110] Lamont, Seasons with the Sea-horses, London, 1861, pp. 86, 163, 165. (I am positive that I have seen the current running among the Thousand Islands at the rate of seven or eight miles an hour.)

111. [111] Compare my instructions of May 6, 1868. ("Geographische Mittheilungen," 1868, pp. 214 and 215.)

112. [112] "Geographische Mittheilungen," 1868, p. 341.

[Captain Gray placed his views before the Royal Geographical Society in the following letter to its President, printed in the Proceedings of the Society, vol. xii, p. 196 *et seq.*—HYDROGRAPHIC OFFICE.]

Letter to Sir Roderick I. Murchison, on a voyage to the Northeast Coast of Greenland. By David Gray, Esq.

"PETERHEAD, *22d February*, 1868.

"SIR: I have been much gratified by observing that the Royal Geographical Society has revived, with earnestness, the question of the propriety of organizing an expedition with the view of reaching the North Pole. I think it is evident that the voice of the country will not permit the important geographical discoveries which such an expedition would undoubtedly effect to be longer delayed; and that, after so much has been done by British seamen to acquire the experience and information requisite for the successful conduct of such an expedition, it is a point of national honor that it should not be prosecuted otherwise than by their energies and exertions.

"As I am about to sail on a voyage to the Arctic seas, and as the question will no doubt receive further discussion in my absence, I may be permitted to offer for consideration the views which much thought and experience of many years of Arctic navigation have led me to entertain regarding the route by which, as it appears to me, the Pole may be most easily reached, with the greatest amount of economy and safety to the expedition which may be engaged in that service. **Note. 112.** (Con'd.)

"The views of Captain Sherard Osborn and the other distinguished navigators who have written and spoken on this subject, and who recommend Spitzbergen, Behring's Straits, and Baffin's Bay as the three routes by which the Polar Sea may be reached, are entitled to every consideration and respect; but I humbly think that none of these possess the advantages of a fourth route, viz, by the east coast of Greenland, which it is my purpose to advocate in this communication.

"Having for many years pursued the whale fishery on the east coast of Greenland, and observed the tides, the set of currents, and the state of the ice in that locality, at various seasons of the year, I think that little, if any, difficulty would be experienced in carrying a vessel in a single season to a very high latitude, if not to the Pole itself, by taking the ice at about the latitude of 75°, where generally exists a deep bight, sometimes running in a northwest direction upwards of 100 miles toward Shannon Island; from thence following the continent of Greenland as long as it was found to trend in the desired direction, and afterward pushing northward through the loose fields of ice, which I shall show may be expected to be found in that locality. The following are the reasons on which that opinion is founded:

"1st. In prosecuting the whale fishery, in the vicinity of Shannon Island, there are generally found loose fields of ice, with a considerable amount of open water, and a dark-water sky along the land to the northward; the land-water sometimes extending for at least fifty miles to the eastward; and, in seasons when southwest winds prevail, the ice opens up very fast from the land in that latitude.

"2d. From the comparative rarity of icebergs on the east coast of Greenland, I conceive that I am justified in inferring that there does not exist any great extent of land to the northward; and, if that inference is correct, I am led to the conclusion that there would be less difficulty in pushing a ship to the northward than if there were comparatively narrow channels to be encountered, as is the case in the route by Smith's Sound.

"3d. The ice on the east coast of Greenland is what is termed field or floe-ice, the extent of which varies with the nature of the season; but it is always in motion, even in winter, as is proved by the fact that ships, beset as far north as 78°, have driven down, during the autumn and winter, as far south as Cape Farewell. Thus there is always the means of pushing to the northward, by keeping to the land-ice and watching favorable openings, without the risk of encountering the fast ice prevailing in Smith's Sound.

"4th. I have observed, on landing on Pendulum Island, early in the month of August, that the rise and fall of the tide did not appear to exceed four feet. On that occasion the land-water extended sixty miles to the southeast, the ice in it being in such a condition that it was scarcely necessary to change the ship's course for it; and on ascending the highest of the Pendulum Islands—the altitude of which may be judged of from the fact that it can be seen from sea at a distance of upward of sixty miles—the open water extended to the northward as far as the eye could reach, with a dark-water sky beyond.

"5th. The current generally sets in a southwest direction, and the drift of the ice, with moderate northerly or northeasterly winds, is from eight to ten

Note.

112-115. miles a day, sometimes reaching, with a strong northeasterly gale, as much as twenty miles a day. Southwest winds, on the other hand, have the effect of causing the ice to open out, leaving large open lanes between the pieces; and I have no doubt the same effects would be felt to the farthest limit of the Greenland coast northward.

"6th. In the event of an expedition prosecuting the route I have recommended, it would certainly, without difficulty and with favorable winds, in not more than fourteen days reach Shannon Island, which would serve for a land-base for its future operations, unless one were desired farther north, which could be obtained. Thus, supposing the expedition to sail in the early part of June, it would reach the field of its operations in six weeks' less time than it would have to reach the entrance of Smith's Sound; and, instead of having only a short time in the month of September available for its object, if it went by the Smith Sound route, it would have before it the greater part of the month of July, the month of August, and the half of September for its work, in which time its object might be accomplished.

"7th. Supposing it were necessary for the expedition to winter, there are apparently many bays and good harbors on the east coast of Greenland available for that purpose; and, from the indications which I have observed, there seems to exist there an average amount of animal life compared with the other Arctic districts.

"It is desirable that, before the dispatch of another Arctic expedition, as many views on the subject should be obtained as possible, and I trust that this may be accepted as my apology for troubling you with this communication.

"I have the honor to be, sir, your obedient servant,

"DAVID GRAY."

[The first German North Polar expedition, under Koldewey, in 1868, attempted to penetrate north on the route recommended by Captain Gray, but failed on account of impenetrable ice which was found blockading the east coast of Greenland, between the parallels of latitude 73° and 76°, at a distance of fifty to seventy miles. (Compare the review of the expedition by Dr. von Freeden, pages 120 and 121 of this volume, and the abstract of the log-book. in note 206.)

The two ships of the second expedition, in 1869, renewed the attempt. The Germania reached the coast, and wintered, 1869–'70, on Sabine Island; she could not, however, penetrate higher on that route than 75° 29′ N. A sleigh party reached as high as 77° 01′ N. The Hansa was beset in sight of the coast and crushed. (See the preliminary report, page 161, *et seq.*—Hydrographic Office.]

113. [113] Manuscript chart of Dr. Dorst, illustrating his cruise in 1869, with his letter, dated Jülich, September, 1869.

114. [114] See the table of currents, in note 201.

115. [115] "Geographische Mittheilungen," 1870, part iv, p. 143.

[The profile of the bed of the Arctic Ocean at Spitzbergen, according to the deep-sea soundings of the Swedish expedition, under Nordenskiöld and von Otter, 1868, by Dr. Petermann. The following passage is referred to:—Hydrographic Office.]

"Of interest are also the relations of the depths and the currents to each other. The course and the extent of the Gulf Stream, and its meeting with the Polar Stream, can be recognized clearly from the batho-thermal lines, (the curves of equal temperature at various depths.) We see here just the same that we perceive in other parts of the globe, where Equatorial (warm) and Polar (cold) currents meet—a shoaling of the sea by the deposition of the débris of earth and rock carried along by the cold stream. A striking instance of it is especially the extensive Bear Island Bank, on which the Polar Stream pushes far to the southwest, until it comes to a nearly permanent rest just beyond the island; here, as at other places, it forms, so to speak, immense glacier tongues which, like the Alpine glaciers, carry along with them their moraines, but drop them to the bottom of the sea, melted and destroyed, as soon as they meet the warmer currents. Where a branch of the Gulf Stream penetrates, there are greater depths than close to where the Polar Stream prevails, as, for instance, between Bear Island and the south coast of Spitzbergen, where the Gulf Stream but just extends a tongue, while the greater arm proceeds north along the west coast of Spitzbergen, causing there the nearly always open, so-called, Whale Bay, until it again meets the Polar Stream at the northwestern corner of Spitzbergen. Here also appear lesser depths to indicate the shoaling tendencies of the Polar Stream." **Note. 115.** (Con'd.)

[The following additional remarks of Dr. Petermann, in regard to the valuable labors of the Swedish expedition of 1868, will also be found interesting:—HYDROGRAPHIC OFFICE.]

"Of great importance are the deep-sea soundings of the expedition and the researches into the physical nature of the deep sea and the bed of the ocean.

"The second Swedish expedition, in 1861, had made examinations to the depth of 1,400 fathoms; the fourth extended them to the enormous depth of 2,650 fathoms. Both these soundings were in the sea west of Spitzbergen, between the parallels of latitude 76° and 79° N.

"It had before been generally believed that the sea shoals gradually toward the North Pole; the Swedes, however, have proved that even Mont Blanc could be sunk in the sea between these high latitudes, without leaving an indication of its site to the passing mariner.

"The most prominent authorities have maintained that all animal life in the sea ceases at a depth of 300 fathoms. They concluded this from the investigations in the depths of the Mediterranean Sea. But Professor Torrel, in his very first deep-sea sounding in the Arctic Sea, in May, 1861, obtained an unexpected abundance of animals from a depth of 6,300 feet; among them *Annelidæ* and *Holothuriæ*, belonging to a class which before was not believed to exist in greater depths. The expedition of 1868 brought up living animals from the bed of the Arctic Sea, even at the depth of 15,900 feet.

"Very important inferences can be drawn from the soundings of the Swedish expeditions. In the first instance they show Spitzbergen to be connected by a submarine bridge with Europe, and thus to be regarded as a spur of the Scandinavian peninsula, and as belonging to Europe, while it is separated from Greenland by a deep basin of water. The sea between the Norwegian coast and Spitzbergen was found to be of no great depth; up to Bear Island not much over 200 fathoms, only in one place 271 fathoms; between Bear Island and Spitzbergen still more shallow, the maximum depth there being only 180 fathoms.

"The western and northern coasts of Spitzbergen, on the contrary, are very steep; the sea has, toward the north, at the distance of only 60 miles from the Seven Islands, a depth of 1,370 fathoms, and 150 miles from the coast, of 2,650 fathoms, (in latitude 78° 25′ N., longitude 2° 30′ W.)

Notes.

115-20. "The greatest depth (1,400 fathoms) measured by Torrel, September 18, 1861, was in latitude 76° 17′ 12″ N., longitude 13° 53′ 54″ E. In this depth, at which water acts with a pressure of 200 atmospheres, where the light does not reach, but air and salt are probably the same as at the surface, he discovered so great a number of animals, and such a variety of species, as in other oceans is only found at the surface. He describes what his dredges brought up near the north coast of Spitzbergen from a lesser depth as follows: 'We were greatly astonished when we saw the strange animal forms which were raised from the depths of this northern part of the Arctic Sea. Our nets and bottom-scrapers were swarming with the colossal "*Crangon boreas*," with their clumpy body and the violent jumping motion; multitudes of tender *Hypolithæ*, myriads of *Merlæ* and *Gammari*, among them sometimes also a fish of the family *Cottus* or *Liparis*. In the clay of the sea-bed, mixed with sand, were queer craw-fish of the *Cuma* family, great numbers of shells and snails, as *Tellina*, *Yoldia*, *Astarte*, and *Tritonium*, inhabited by large worms of variegated, glistening colors, *Terebella*, *Nephthys*, *Phyllodore*, *Polynoë*, and others. To such sights we were by no means accustomed, as such an abundance of luxuriantly-developed species is not found on our coasts. The Arctic Sea, in some places, is literally a pulp of millions of living animals." (Compare the Swedish expeditions to Spitzbergen and Bear Island, 1861, 1864, and 1868, 5th volume of the "Bibliothek Geographischer Reisen und Entdeckungen"; Jena, Costenoble, 1869.)

[For an account of the expedition see note 56.—HYDROGRAPHIC OFFICE.]

116. [116] Lamont, Seasons with the Sea-horses, p. 164.

117. [117] See pages 50 to 52.

118. [118] Proceedings R. Geog. Soc., ix, p. 177.

119. [119] Middendorff "Sibirische Reise," iv, part 1, p. 508.

120. [120] Wrangell, "Reise längs der Nordküste von Sibirien," p. ii, p. 252, (Narrative of an Expedition to the Polar Sea, translated by Colonel Sabine, London, 1844, p. 504,) where the following is stated:

The great Polynia, or the part of the Polar Ocean which is always an open sea, is met with about 25 versts (about 14 nautical miles) north of the islands of Kotelnoi and New Siberia, and from thence in a more or less direct line to about the same distance off the coast of the continent, between Cape Chelagskoi and Cape North. Tatarinow, who accompanied the Surveyor Pschenitzyn to New Siberia in April, 1811, found an open sea about 25 versts north of that island; as did Hedenström in 1810, about 70 versts east of it. Lieutenant von Anjou, in 1823, traced the boundary of the open sea some miles to the north of these islands, as is shown by his track in the map annexed to this work. Our several journeys have related the various instances in which we encountered either the open sea itself, or the very thin ice indicative of its immediate vicinity, at different points of the general boundary-line above described. The Tchuktchis, who live near Cape North, when speaking of the polynia in that neighborhood, added that the shore-ice usually extends somewhat farther seaward about Cape North than about Cape Jakan. Our frequent experience that north and northwest winds, and open northeast winds also, are damp to a degree which was sufficient to wet our clothes, is also a corroboration of the existence of an open sea at no great distance in those directions. During the summer the current between Swatoi-Noss and Koliutchin Island is from east to west, and in autumn from west to east. This is confirmed by the relations of Liakhow in 1773, Schalarov in 1762, and Billings in 1787. The Tschuktchis also told us that in summer the ice drifts rapidly along the coast to the west, and in autumn to the east. The prevalence of N. W. winds is doubtless the occasion of the S. E. current which we frequently observed in the spring. **Notes. 120-23.**

[121] Erman's "Russisches Archiv," vol. xxiv, 1865, p. 128. The book of Hedenström, the discoverer of New Siberia, appears to be now very rare, although two editions have been published, a Russian and a German. We vainly endeavored, in Germany as well as in Russia, to obtain a copy, if even only for examination. Professor Erman, who possesses perhaps the only copy outside of Russia, had the goodness to republish, at my request, the chapter on the Arctic Sea in the Archive. **121.**

[122] Erman, besides other places, p. 135. **122.**

[123] "Geographische Mittheilungen," 1869, p. 392. **123.**

[The author refers here to the following preliminary report of Captain Palliser, dated Drontheim, September 22, 1869, and published in the Athenæum of October 16, 1869.—HYDROGRAPHIC OFFICE.]

"STEAMER KONG CARL, OFF DRONTHEIM, *September* 22, 1869.

"I have come back safe and sound after a pleasant tour. We started very late from Drontheim, owing to many things necessary to be done to the ship, and did not arrive at the island of Nova Zembla until the end of July. The ice was not then broken up, but we experienced very stormy weather and heavy southwest gales, which terminated in the general breaking up of the ice which disappeared entirely. We had, previously to this, gone north about half a degree of Cape Nassau, looking for walruses. We then turned back, but could find no good anchorage. We were, however, able to fasten our ice-anchors to the fast ice. It was while lying so anchored that the ice broke up. We were in some little danger and considerable difficulties while this was taking place, owing to the stormy weather and heavy current; but after the ice broke up and disappeared I think we could have gone and sailed around Nova Zembla easily enough, but we were hampered by a wrecked crew we had to save and take on board, which would have prevented our provisions holding out long enough; so we turned south, not going into harbor till we came to the mouth of Matthew's Straits. Then I lowered the steam launch, (a boat about 24 feet long,) and, getting up steam and taking the two fangst-boats in tow, ran through the Matthew's Straits, but there was no ice to be seen, either in the Matthew's Straits or in the Kara Sea beyond. A fearful storm came on, at the termination of which I sent back the Laurel, with directions to the captain to take the ship through and to join us in the Kara Sea, which he did, and then we got

Note.

123. (Con'd.) almost all our fangst, consisting of 49 walruses, 25 seal, 1 whale, and 14 polar bears, one of which, a fine female cub, we caught alive, and have brought on with us. After this we went to the north end of the Samoide Peninsula, within three or four miles of White Island, with the intention of going round into the Gulf of Obi, but the water was so shallow we could not venture on, as it was blowing a severe gale from the northwest, and the captain said that if the wind shifted round to the west we should not any longer be able to beat off, but would get on the quicksands, the presence of which we could already detect from our lead. I was greatly annoyed at not being able to get round into the Gulf of Obi. On our return to Tromsö we met Lamont in his beautiful steam-yacht. We returned through the Waigats Straits, obtaining, during a heavy storm, pretty good anchorage at Waigats Island; afterward, by the aid of a fine northeaster, we came on and ran 36 miles into Hammerfest and Tromsö Fiord in twenty-four hours.

"JOHN PALLISER."

Captain Palliser's cruise is of great interest. Shortly before him the Norwegian fisherman Carlsen had, after passing through the Waigats Straits, penetrated deep into the Kara Sea, which hitherto was believed to be always full of ice, and had sailed along the Siberian coast to within a few miles of White Island, off the mouth of the Obi, without encountering a single flow of ice, or even being able to see any indication of ice, as far as the eye could reach. ("Geographische Mittheilungen," 1869, p. 352.)

Had Carlsen's experience remained the only instance, it might be considered a rare exception from the rule, perhaps a happy accident; and eminent authorities even had expressed their doubts of the reported fact, but Palliser's report fully corroborates Carlsen's statement. The latitude reached by Palliser before the ice broke, half a degree north of Cape Nassau, is a very high one for this icy region. Palliser's account of the immense effect of the storm upon the ice, the destruction and disappearance of it, accords entirely with the more detailed observations of Dr. Dorst farther westward.

From the fact that Carlsen could penetrate along the Siberian coast as far as the mouth of the Obi, it might have been assumed that the ice of the Kara Sea, driven off this coast, must have accumulated on the east coast of Nova Zembla; the more striking is it, therefore, that Palliser, after having passed Matthew's Straits or Matotchkin Schar, did not find ice there, and that he could go in a straight line across the Kara Sea to the Obi. As far as known to us, no other navigator has ever done so.

A. PETERMANN.

[A still more decisive confirmation is the cruise of the Norwegian fisherman Johannesen whose diary has been published, subsequent to the above, in the "Geographische Mittheilungen," for 1870, p. 193. On account of its value, and in order to show how very useful information may be gathered by masters of whalers in the ordinary pursuit of their trade, it is translated entire.—HYDROGRAPHIC OFFICE.]

Cruise of Captain Johannesen in the Kara Sea, 1869.

May 31. I reached Nova Zembla and came to anchor on the south coast of Mesduscharski Island; there was no drift-ice there, but some attached to the coast.

June 2. Made sail, steering south; no drift-ice, but some ice fast to the land; shoal water along the coast, 8 and 12 fathoms, to a distance of one mile from the shore; deeper water along the southern coast, but rocks close in shore. Note. 123. (Con'd.)

June 3. West of Kabanji-Nos, where there was some drift-ice. From there turned back, sailing along the west coast of Nova Zembla.

June 4. No ice.

June 5. About the middle of the Geese coast; some floe-ice.

June 6. At the northern Geese Cape; thicker ice a mile off shore, but none fast to the land.

June 7. Crossed Moller Bay; a mile off shore loose drift-ice.

June 8. No ice.

June 9. Passed the mouth of Matotshkin Shar, (Matthew's Straits;) no ice seen.

June 10. Passed Suchoi-Nos and reached Cross Bay, (Krestowaja Guba;) no ice a mile from the shore and no bottom at 60 fathoms. Variation 16° E.

June 12. At Cape Raarfaava, (Cape Schanz?) four miles off shore, at the ice-barrier. No ice toward the land.

June 14. At the Admiralty Peninsula, three to four miles off shore; no ice.

June 15. No ice.

June 16. Passed the Cross Islands; some pieces of drift-ice three-quarters of a mile from the shore; no bottom at 25 fathoms.

June 17. Off the Pankratjew Islands; a mile off shore no bottom at 60 fathoms; no ice seen.

June 18. Sailing north; some pieces of drift-ice.

June 19. Arrived at Cape Nassau; found the ice-barrier to be distant a mile from the cape, extending in a northwest and northeast direction, but quite thin. The current is strong and sets to the east; I therefore turned back to the south. So strong a current as at Cape Nassau I had observed nowhere to the south of it.

June 20. At Barents Island, steering south; found the ice alternately thick or loose, according to the weather; winds from the south and the west.

From the 20th of June to the 12th of July continued south; along the coast, from Barents Island to Birch Island, I found the ice alternately thick or diffused. From Birch Island to Matotshkin Shar the coast was free of ice to a distance of four miles, where the barrier was thick and impenetrable.

July 17. I sailed through Matotshkin Shar, sounding in 5 to 15 fathoms; sand and clay; found a strong current.

July 18. I reached the eastern end of the straits, and sailed thence south, along the east coast of Nova Zembla; nowhere was ice to be seen, and the air was mild. After making Waigats Island, (the northwest point of which I observed to be in latitude 70° 21′ 43″ N., longitude 58° 15′ E. of Greenwich,) I arrived at Cape Mentschikow on the 28th, and steered thence northeast, to cross the Kara Sea.

July 28 and 29. Some diffused ice, (latitude 71° 03′ 46″ N., longitude 59° 22′ E. of Greenwich,) which had disappeared entirely at noon of July 29; no bottom at 30 fathoms; wind S. and S. E.; thick air, fog; by dead reckoning in latitude 71° 12′ 22″ N., longitude 63° 54′ E.

July 30. In latitude 71° 14′ 40″ N., longitude 65° 08′ 24″ E., shoal water, from 20 to 7 fathoms; clay, pebbles, and mud, with grass; no ice; the weather dark and foggy; wind S. W.

Note. 123. (Con'd.) August 1. In latitude 71° 01′ 56″ N., longitude 65° 35′ E., at the Scharapow Banks. The land is low, utmost six feet above the level of the sea; at flood-tide below water. Three miles off shore there are 8, 9, and 10 fathoms; closer in, 12 fathoms; half a mile off shore, 8 fathoms. A little north of Cape Sharapow, tents of the Samoieds were seen in groups of four; also animals, probably reindeer. The land there was higher, the coast rising steep-to about sixteen feet; three miles off shore, 10 to 12 fathoms of water; no ice.

August 3. Proceeded north along the Samoied coast, but at such a distance the land, which is low, was only at times in sight from the mast-head when within less than four to six miles. Some ice which, however, was destroyed entirely within six hours by a gale from the west; depths, 10, 12, and 13 fathoms.

August 4. Saw the coast near Cape Eblarma, and on it Samoied tents; the depth beyond the sight of land was only 13 fathoms; closer in, 7 fathoms; no ice.

August 5. Off Cape Pyindje; land in sight and some thin drift-ice; 10 fathoms water three or four miles off the coast.

August 6. Latitude 72° 49′ N., longitude 68° E.; 11 to 12 fathoms water at the distance of four to six miles from the shore; farther out, 7, 8, 10, and 12 fathoms; no land in sight; single strips of ice fast to the bottom; none to the west.

August 7. Some ice; the west coast of White Island in sight. This island is very low; utmost six to eight feet above the sea. The current there sets to the north, as is the case along the entire Samoied coast. Ebb and flood tides not so strong as at Tromsö. With the land in sight from the mast-head, 9 fathoms water.

August 8. About three miles off the northwest point of White Island, 5 fathoms water. Current northeast, one to two knots; in this direction it is always strongest and most constant; southwestern currents are weaker. Nowhere was ice to be seen, the air being too mild for it. White Island had a green appearance, with the exception of the sandy west point. The entire Samoied coast, in general, was found to be covered with grass, but trees were not seen.

From the northwest point of White Island I steered northwest, on account of the shallow water. The bottom of the sea consisted of sea-grass, sand, and mud, but mostly of grass-banks.

August 9. Latitude 73° 54′ 50″ N., longitude 69° E.; continued northwest; 12, 10, 8, and 9 fathoms water; no ice; bottom clay and grass-banks.

August 10 and 11. Some ice drifting from N. E. to S. W.; 16 to 18 fathoms water.

August 12 and 13. Nineteen fathoms; no ice; steering northeast.

August 14. Some ice; 19 to 20 fathoms water.

August 15. Latitude 75° 06′ 15″ N.; longitude, by reckoning, 71° to 72° E.; some drift-ice in a northern direction; 13, 16, 18 fathoms water, but soon no bottom at 25 fathoms. The state of air indicated that no ice could be in a northeastern, and but little in a northern direction.

August 16. Latitude 75° 05′ 57″ N.; longitude, by reckoning, 71° 30′ E.; some drift-ice; 15 to 16 fathoms water.

August 17. Steered southwest; single strips of ice; 17 fathoms water; then no bottom at 25 fathoms.

August 18. Course S. W.; some drift-ice; no bottom at 25 fathoms.

August 19. Latitude 74° 58′ 51″ N.; longitude, by reckoning, 65° 30′ E.; 116 fathoms water; bottom muddy clay. Notes. 123-25.

August 20. Steered north; latitude 75° 10′ 17″ N., longitude 64° E.; east coast of Nova Zembla in sight.

August 21. Landed at 4 p. m.; coast low; no grass; in places ice piled up, but no drift-ice; drift-wood on some of the sandy points; the sea is deep close to the coast, 35 fathoms one-quarter of a mile off; there are no rocks nor banks.

Steering south along the coast, we made Cape Distant August 23. Nowhere was ice to be seen on the sea, and there was a heavy swell from the southeast.

August 24. Reached the Pachtussow Islands, and sounded between them in 100 fathoms. Thence proceeded southward, following the coast which is low, without outlying rocks. Between Cape Distant and the Pachtussow Islands some reindeer were seen.

August 28 and 29. At the Matotshkin Schar, and—

September 1. At the Kara Straits.

In regard to the ice, I have yet to remark as follows:

The Russians say that there is no ice along the Samoied coast in summer, until it freezes in autumn. The correctness of this assertion is supported by the fact that all the drift-ice which has been observed was thin. But along the east coast of Nova Zembla, north of Cape Menschikow, drift-ice was found lying in a northern and northeastern direction, and, according to the statements of the Russians, it remains there the entire year; because, as some explain it, the currents from the Kara Sea, and the Obi, and other rivers, force it to remain there. As the current from the rivers east of the Obi and from the Obi sets toward the east end of Nova Zembla, and a part of this current runs thence past the southeast end to the west, while the other part flows past the north end into the Arctic Ocean, that part running along the east coast of Nova Zembla meets the current from the Kara Sea, retaining thus the ice in this position. In 1869, however, the western gales kept the Kara Sea free of ice.

The shallowness of the sea at White Island is caused by deposits from the Obi River, the current from the Obi meeting there the current which flows north along the Samoied coast.

[It will be observed that these three reports, that of Palliser, Carlsen, and Johannesen, refer to the same locality, and to the same season, the summer of 1869.—Hydrographic Office.]

[124] Geographische Mittheilungen, 1870, v, p. 198. See the above diary of Captain Johannesen. 124.

[125] In regard to Dr. Bessels' expedition compare the two letters of Dr. Bessels to Dr. Petermann published in the "Geographische Mittheilungen of 1869, p. 351, *et seq.* The following are the passages referring to the subject:—Hydrographic Office. 125.

Spitzbergen, to the west of the South Cape, *July* 31, 1869.

Latitude 76° 22′ N., longitude 7° 30′ E. of Greenwich.

As to our cruise and the state of the ice I have to report as follows: The first loose drift-ice we met June 7th in latitude 72° 10′ N., longitude 4° 00′ W. On the 8th, in latitude 72° 22′ N., longitude 4° 00′ W., we came to packed ice, in which no opening was found as far as 74° 10′ N., although we kept close to its border, as you will perceive from the accompanying hurriedly drawn sketch,

Note.
125. which will serve your purposes better than a description. The outer (western-
(Con'd.) most) line represents the ice-barrier as we found it on our first visit; the next inward is the barrier found on our second visit; the third, easternmost, that seen on our third visit.

Where, between latitudes 74° and 76°, the line is broken, there appeared to be a deep bay, the head of which we could not see; the weather, however, was foggy, and the radius of visibility not great. Further north there was everywhere thick ice.

The highest point, latitude 80° 14′ N., longitude 9° 52′ E., we reached June 20th. As far as the eye could see there was thick, impenetrable ice. To penetrate from here to Gillis Land was utterly impossible.

As it blew constantly strong from the south, we remained for a few days at anchor off Smeerenburg, in hopes that the ice might set further north; but in vain. In making the second attempt we found the ice as thick as before. We had to abandon our intention to reach the Hinlopen Strait from the north.

The thick packed ice which we had found on the southwest coast of Spitzbergen on our first visit, had disappeared when we came there again, on the 30th of July. Although our seamen did not believe in it, I can but uphold the opinion that the southern limit of the northern ice was pressed downward, so far as we found it on our second and third visits, only by huge masses of ice which had borne against it. There was now no ice from the South Cape to Carl's Foreland. It had been blowing strong from the south and south-southeast, and nevertheless the northernmost limit of ice was nearly two degrees further south than before. I believe my supposition to be the more correct, as it is the most natural. * * * * * * *

Bremerhaven, *September* 24, 1869.

I now will report briefly the results of our cruise. For my own branch of science I could do but very little; for you I was able to do more. I recorded for every fourth hour the height of the barometer, the temperature of air and water, the wind and the weather, with a description of the clouds. From these data, and especially from the observed temperatures of the sea, some valuable results will be obtained. I could not, for the want of instruments, ascertain the density of the water; I bring home, however, water from various depths of various localities, which can be analyzed to ascertain the proportion of salt contained in each specimen. An ice-chart constructed on a large scale, and on which the courses are marked, I will place before you at Gotha. I sketched views of the ice and the shores, where they had any remarkable character, but I could not obtain good photographic views, as my developer did not work and I had not chemicals for a new one.

Our attempts to penetrate from the southeast of Spitzbergen to Gillis Land were equally in vain as those from the north. We were not even able to reach the Thousand Islands, as we encountered the southern limit of the ice in latitude 76° 50′ N., between the meridians of 18° and 25° E. of Greenwich; and also Hope Island (the southern point of which we determined to be in latitude 76° 35′ N., longitude 25° 47′ E., 34 minutes more to the southward than placed on the Swedish chart) we could not visit. In latitude 76° 00′ N., longitude 22° 00′ E., we found but 24 fathoms water. A bank appears to extend from the Thousand Islands to Bear Island, and thence probably still further south; and there were in general no considerable depths to 59° E. of Greenwich. By attaching a small net to the lead I obtained good specimens of the bottom and some minute animals. **Note. 125.** (Con'd.)

We did not land on Nova Zembla. While in the vicinity of its coast we had always a high sea, and frequently so very thick fog that nothing could be seen at the distance of 20 paces.

On our way to Nova Zembla we kept as far as possible along the thick ice-barrier, the northernmost point of the southern limit of which is in latitude 76° 50′, extending to longitude 56° E. In general the ice was much thicker east of Spitzbergen than west of it, which must be ascribed to the high sea coming from the south. The highest point reached by us in the east was in latitude 76° 45′; perhaps we may have gone beyond that, as appears to me from observations obtained two days after, when the sun came out; if so, the limit of the ice lies higher than stated above. The thick ice-barrier extends in a wide bight to the headland west of Cape Nassau. The latter we could see clearly for a few minutes, but could not reach it. On the 20th of August we turned homeward.

[With these two letters is also published the following of Dr. Dorst, giving the summary of the examinations in Mr. Rosenthal's steamer "Bienenkorb," referred to frequently in Mr. Petermann's memoir:—HYDROGRAPHIC OFFICE.]

JÜLICH, *September* 19, 1869.

The main purpose of our expedition, viz, to reach the east coast of Greenland, has not been attained, although we tried our best. Each bight in the ice, each loose part of the ice, was forced, in order to break through, and Captain Hagens deserves really the fullest credit for it; but the state of the ice was more unfavorable, according to all Greenland cruisers, as Dr. Gray, Westermeyer, Gray's son, &c., than it had been for the last ten years. To mention only one fact: Captain Gray, between latitudes 73° and 74°, and longitudes 14° and 15° W., pressed his beautiful ship—as large as the Albert, and of little less horse-power—with full steam and under all sails, into the ice, to push through it to the coast, but had to desist after seriously injuring his screw, so that he lost 3½ miles per hour in speed; and he soon found the ship beset, notwithstanding all his pains and hard labor. He remained fast three to four weeks, although trying constantly, by warping, &c., to free himself; he succeeded finally when near Jan-Mayen.

From the Germania and the Hansa (the vessels of the second German North Polar expedition) you have heard, in the mean time, directly. I can but add that the day after meeting for the last time the Germania, we saw the Hansa fast in the ice; unfortunately, we could not, on account of the intervening ice, approach her. [The Hansa remained fast, and was abandoned subsequently by her crew. See Appendix, page 181.]

As to my own results, they are briefly as follows: The physical relations of the ice, and especially its movements, were carefully investigated. The density of the sea-water was ascertained by an areometer each day twice; in the spring, between the young bay-ice, it was found surprisingly high, 1.0315. The temperature and the density of the sea-water in greater depths, to 150 fathoms, was also examined. There were further, each alternate hour of the day, observations made of the barometer, psychrometer, of the temperature of the surface of the

Notes.

125-26. sea, of the wind, and of the clouds; as also an excellent metal barometer read in order to ascertain the increase of gravity with the latitude, according to Wüllersdorff, (Voyage of the Novara, physical part, preface, page x,) as also for other purposes.

Animal life was duly observed, and notes taken in regard to it. Some pine-wood logs, more than one hundred years of age, glass balls from the Lafotes, and some minerals, were found on the ice.

A great number of magnetic observations were made on the ice and on board, and numerous specimens of sea-water from greater depths procured in order to examine them at home.

Many zoölogical specimens were preserved in alcohol, bird skins collected, in general, everything deserving notice was observed and recorded. I also have drawn many sketches of Jan-Mayen, measured by sextant the height of Berries Mountain, and sketched auroræ boreales, of which many were seen in the spring.

On the whole, I may well be satisfied with the scientific results of the expedition.

126. [126] Geographische Mittheilungen, supplement No. 16, p. 12.

Barto von Löwenigh, burgomaster of Burtscheid, undertook, in a hired yacht manned with but six persons, a voyage from Hammerfest to Spitzbergen, and back again, from the 10th of August to the 27th of September, 1827. He was accompanied by the Norwegian savant Keilhau, who published a very interesting and important account of the cruise—"Keilhau, Reise i Ost og Vest Finmarken samt til Beeren-Eiland og Spitzbergen. Christiania, 1831." An abstract of it will be found in the "Geographische Mittheilungen," supplement N. 16, p. 39, *et seq.* Compare also note 98.

Birkbeck and Newton visited Spitzbergen in August, 1864, and sailing from there east, came in sight of Gillis Land, which had been seen by the Swedish expedition from the White Mountains (3,000 feet high) in East Spitzbergen, and by Carlsen from the Northeast Land, and had been placed in about latitude 79° N., and longitude 28½° E. of Greenwich. Newton, however, says that it extends from that point about 100 miles to the southward, to latitude 77° 20′ N., and that an island, 40 miles in length, lies before it, which he named Helina Island.

Of Lamont's voyage, in 1858, there is, besides his own book, the following short account in the "Geographische Mittheilungen," for 1859, p. 308, taken from the journal of the Geographical Society of London, June 15, 1859:

"Arrived at Spitzbergen, Lamont sailed into the Stour Fiord, which he found to be not a gulf, but a sound, dividing the island. The first thirty miles of the coasts of this sound were steep faces of two or three immense glaciers. The water is shallow, generally less than 16 fathoms, and this appears to be so around the whole of Spitzbergen, so that very large icebergs cannot form. The formation of the coast is such that there first extends a shallow, muddy strand, from a half to three miles in width, frozen from twelve to eighteen inches deep, or covered by ice. This strand is intersected by muddy water-courses, in which saxifragæ, mosses, and algæ grow, the food of reindeer; at some places rocks of trap-formation break through to the surface. Beyond this strand there is a muddy but steep slope, ascending to vertical slate-rock, over which the great glaciers extend, overtopping them; if there is no fog, peaks are seen, consisting probably of granite. In the upper part of the sound much drift-wood is found, especially thin pine trees, decayed and water-logged, also pieces from wrecks; bones and whale skeletons are numerous. Some miles inland, also, and at least thirty feet above high-water mark, drift-wood and whale bones are found; also on the Thousand Islands, high on the land. From these circumstances, and from the fact, ascertained by seal fishers and whalers, of the sea getting more shallow around Spitzbergen, Lamont concludes that Spitzbergen and the neighboring islands grow up above the sea, and with great rapidity, as has been proved for some parts of Norway." Notes. 126-27.

[Mr. Lamont undertook, in 1869, a second expedition, which returned to Scotland October 6. He reached Nova Zembla in May, and Spitzbergen in June, but found there an unusual accumulation of thick and heavy ice, which did not permit him to go higher than 80° N. Of the scientific results of the expedition nothing is published so far.—HYDROGRAPHIC OFFICE.]

[127] Geographische Mittheilungen, 1865, pp. 139 and 140. 127.

[The passages referred to are the following. Compare also "Sir James Ross's Voyage of Discovery and Research in the Southern and Antarctic Regions, 1839 to 1843. London, 1847." Vol. i, pp. 172 to 182, and vol. ii, pp. 155, 182, 189.—HYDROGRAPHIC OFFICE.]

Sir James Ross penetrated, in two places, farther southward than all before him (Cook, Bellinghausen, Balleny, and Wilkes) had considered possible. The first time, the barrier of packed ice was met January 1, 1841, in latitude 66° 32′ S., longitude 169° 45′ E., but "it presented none of those evidences of impenetrability we had been led to expect from the accounts of former expeditions;" and although weather and wind drove the ships directly against the ice, and a retreat to the open water would probably have been impossible, they pressed, January 5, in latitude 66° 45′ S., longitude 174° 34′ E., fearlessly into the pack. After the outer edge "which, as usual, was formed of much heavier ice than the rest," had been broken through, "we found the ice much lighter and more scattered than it appeared to be when viewed from the distance. It consisted chiefly of small floes of ice, of last winter's formation, with a quantity of hummocky ice of much older date, formed by great pressure into very heavy masses; but it was by no means of so formidable a character as we had been led to expect from the accounts we had received of the southern barrier in those parts where the American and French expeditions had encountered it. With a clear sky above us, we pursued our way through the pack, choosing the clearest 'leads' and forcing the interposing barriers as they occurred. On the 6th and 7th, however, the ice became so thick that we were obliged to heave-to in a small hole of water, out of which we could find no way to the southward. In the evening of the 7th the ice slackened a little, and we bored through it seven or eight miles to the southeast, toward an encouraging dark-water sky that we had seen on the day previous. On the 8th a great change in the ice was produced by the calm, opening it out in all directions, as we always had found to be the case in the Arctic seas; and a breeze springing up from the northward at 8 p. m., we made some way through the pack, pressing forward under all sail to the southeast water. We sustained many severe shocks in breaking through the interposing barriers of closer ice. Thick weather and snow prevented our seeing to any distance before us, or selecting our way, while the increasing breeze impelled us rapidly onward, so that, at 5 a. m. the next day, we had accomplished the object of our exertions and found ourselves again in a clear sea."

Note.
127. (Con'd.) The width of this barrier of pack-ice, through which Sir James C. Ross worked so successfully in four days, amounted to about 130 miles.

The second time, he pressed through the barrier of pack-ice twenty-five to forty degrees east of this, entering it in about latitude 61° 45′ S., longitude 146° 30′ W., and reaching again the open sea in latitude 67° 45′ S., longitude 159° 30′ W. It required not less than forty-six days, from December 18, 1841, to February 2, 1842. The details of the voyage through this immense ice-belt (see the second volume of the narrative, pp. 145 to 188) cannot be given here. It will be sufficient to remark that it was by no means a drifting with the ice, but a working and boring through and against it; often at the same time against wind and current, and this all in a heavy sailing vessel, without the aid of steam. These vast masses of ice occupied six degrees of latitude, but being traversed obliquely the distance made through them amounted at least to 500 miles.

It is of highest importance for geography, and for the further exploration of the Polar regions, to investigate what Ross found on the Polar side of that ice-belt, which all navigators before him (Cook, Bellinghausen, Balleny, Wilkes, D'Urville, and others) had considered and emphatically stated to be an impenetrable barrier to any further progress. According to common prejudice, he should have found a progressive increase of ice and cold, and still greater difficulty of navigation; but this was by no means the case, as Ross himself, a man combining with courage great experience and a clear conception of the laws of nature which rule in the Polar regions, very correctly anticipated when in the pack, surrounded by all the dangers and terrors of the ice. He says, in the beginning of the third year of his voyage: "Notwithstanding the inauspicious circumstances in which we were placed, the arrival of the new year was hailed by us all with the same feelings of confident hope and cheerfulness which had animated our exertions throughout the last season's operations in these regions; and although we had found the pack to extend much farther to the northward than on the former occasion, and were at this time beset in so dense a portion of it that not the least hole of water could be seen among it, presenting to our view an apparently impenetrable mass, so far as the eye could discern from the mast-heads of our ships; yet we were encouraged to hope that the clear water was at no great distance to the southward of us, for we found the ice in which we were inclosed continue to move to the northward before every southerly breeze; it must, therefore, have left clear water at the place it originally occupied and from which it was drifting."

The anticipations of Sir James Ross were entirely correct, because he had found twice beyond the ice-belt an open sea, in which he could sail without difficulty thousands of miles. In the first year there was, after emerging from the belt, "not a particle of ice to be seen in any direction from the mast-head;" and on the next day the discovery of Victoria Land, with its gigantic mountains, reaching the height of Mont Blanc, "restored to England the honor of the discovery of the southernmost known land, which had been nobly won by the intrepid Bellinghausen, and for more than twenty years retained by Russia." From then, uninterruptedly, interesting discoveries were made, the more wonderful as nothing had been expected there. On the same day the expedition landed on Possession Island, which was found completely covered by myriads of penguins and "a deep bed of guano, which had been forming for ages, and which may, at some period, be valuable to the agriculturists of our Australian colonies."

Notes.

Further, "a great number of whales were observed; thirty were counted at one time in various directions, and, during the whole day, wherever you turned your eyes, their blasts were to be seen. Hitherto beyond the reach of their persecutors, they have here enjoyed a life of tranquillity and security, but will now, no doubt, be made to contribute to the wealth of our country in exact proportion to the energy and perseverance of our merchants. A fresh source of national and individual wealth is thus opened to commercial enterprise, and if pursued with boldness and perseverance, it cannot fail to be abundantly productive." At another place (I, 266) it is said: "We saw a great many whales wherever we came near the pack-edge, chiefly of a large size; and I have no doubt that, before long, this place will be the frequent resort of our whaling ships, being at so convenient a distance from Van Diemen's Land, which affords every means and facilities for their equipment." 127-31.

On sailing farther south, through "a sea entirely free from icebergs and drift-ice," another remarkable discovery was made—the two high volcanoes, (10,000 to 12,000 feet,) emitting flames and smoke. Here, finally, further progress was stopped by a perpendicular ice-wall, resting doubtless on a low coast of this volcanic region.

Although, in the second year, the long and tedious captivity in the pack-ice left for the progress to the south but a few days of the least favorable part of the season, nevertheless an equally open sea was found, which the expedition traversed both ways in a few weeks, reaching even a higher latitude than the first year, viz, 78° 09′ 30″ S., the highest reached to this day in the Antarctic region. The ice-wall also was followed ten degrees of longitude to the eastward of the point at which, in the year before, the progress was blocked by the pack-ice.

All this proves that, even in the highest latitudes, the masses of ice occupy but a relatively small space of the ocean; that they continually change, drifting toward the Equator and gradually disappearing, and that they are not an impenetrable obstacle for a Polar expedition. The various explorers found the pack-ice not only in different places each year of their cruise, but it is proved also by Sir John Ross that it changes its place totally during the short space of a few weeks; where, in January, 1841, he had to work through a compact mass of ice 130 miles in width, he found, on his return in the beginning of March, an entirely free sea; and again, farther east, where, in February, 1852, he had encountered that immense ice-field of 500 miles in extent, the sea, only four weeks later, was completely open and navigable, and nearly entirely free of ice.

[128] Geographische Mittheilungen, supplement No. 16, p. 14. 128.

[129] Geographische Mittheilungen, 1865, pp. 214 to 216, (instructions.) 129.

[130] Middendorf, Sibirische Reise, vol. iv, part 1, p. 368. 130.

[131] Geographische Mittheilungen, 1870, v, pp. 194 to 199. [Compare Johannesen's diary, note 123.] 131.

Notes.

132–43. [132] Geographische Mittheilungen, 1869, pp. 352, 391, *et seq.* [The accounts of Palliser's and Carlsen's cruises, to which reference is had here, will be found in note 123.]

133. [133] Bastian and Hartmann, Zeitschrift fur Ethnologie, first year, p. 177.

134. [134] Middendorf, Sibirische Reise, vol. iv, part 1, p. 508.

135. [135] Wrangell, Reise längs der Nordküste von Sibirien, ii, pp. 252, *et seq.* [Narrative of an expedition to the Polar Sea, translated by Colonel Sabine, London, 1844, p. 504; the citation is copied in note 120.] Ermann Russisches Archiv., xxiv, 1865, p. 128.

136. [136] The intense cold of the Siberian winter is the cause of a formation of ice in the sea washing its north coast, the like of which can perhaps nowhere else be found. When the gigantic Siberian rivers throw off in spring their coats of ice, they carry on their long course immense masses of ice from southern latitudes toward thenorth. (W. Dove, inthe "Abhandlung über die Monats Isothrmen," Berlin, 1849, p. 24.)

137. [137] Geographische Mittheilungen, 1869, p. 36. [The citation from Wrangell, copied in note 120, is referred to.]

138. [138] Middendorff, Sibirische Reise, vol. ii, part 1, p. 381.

139. [139] Geographische Mittheilungen, 1869, p. 35. [The passage referred to will be found in note 4.]

140. [140] Wrangell, Reise längs der Nordküste von Sibirien, ii, p. 69. [Narrative of an expedition to the Polar Sea, translated by Colonel Sabine, London, 1844, p. 240.] We found here a strip of ice bare of snow, running along the margin of a new crack in a W. N. W. direction. Having driven five versts on this smooth pathway, we were astonished by falling in with old sledge tracks which, on examining, we recognized as those of our journey in the preceding winter. As by our reckoning we were thirty-five versts (about twenty miles) from our last year's route, it is probable that the N. W. wind, which prevails throughout the summer, had caused the whole field to drift thus far to the eastward.

141. [141] Ausland, 23d April, 1870, p. 408.

142. [142] Compare the chart of Spitzbergen in the Geographische Mittheilungen, supplement No. 16, table 2.

143. [143] The Swedischen Expeditionen nach Spitzbergen, Jena, Costenoble, pp. 159,

Notes.

167, 189, 194, 226, 229, and 364. Geographische Mittheilungen, supplement No. 16, p. 31. 143-52.

[144] The Swedischen Expeditionen, &c., p. 171. 144.

[145] The same, p. 194. 145.

[146] Athenæum, 11th December, 1852, p. 1359. [From a paper by A. Petermann: "Baffin's Bay and the Polar Basin:"] 146.

In the absence of sufficient actual explorations of the Polar seas, nature herself has supplied us, in the immense masses of drift-wood, with so many track-bottles which indicate the direction of the currents. Who would conjecture that the table to which the governor of Disco Island sits down is made of drift-wood which came from Siberia, perhaps from the frontiers of the Chinese Empire? For the Siberian forests are the chief sources of the Arctic drift-wood which, coming down from the great rivers, launches into the Polar Sea, and is borne by a steady current toward Greenland, all along its eastern shores and round the southern extremity to the north, along the greater part of its western shores, so far as Disco Island and beyond it, a distance of more than 4,000 miles.

[147] Zeitschrift für Allgemeine Erdkunde, 1854, vol. 3, p. 189. Compare also the valuable memoir of Gumprecht, "Die Treibprodukte der Strömungen in nord atlantischen Ocean," in the same, pp. 409, *et seq.* 147.

[148] Lamont, Seasons with the Sea-horses, pp. 87 to 91, (containing remarks in detail on the drift-wood and the currents.) 148.

[149] The Reader, April 8, 1865, p. 406. [From an abstract of Notes on Spitzbergen, read by Mr. Alfred Newton before the Philosophical Society of Cambridge, February 27, 1865:] 149.

"Mr. Newton then proceeded to remark on the drift-wood with which the shores of the Thousand Islands are strewn, which he believed to be certainly of Siberian origin, and not brought, as some imagine, by the Gulf Stream; stating that, though often worm-eaten, he had never observed any signs of barnacels upon it."

[150] Geographische Mittheilungen, 1868, p. 217, (instructions.) 150.

[151] Geographische Mittheilungen, 1870, p. 196. [Compare Agardh's memoir, "The Origin of the Spitzbergen Drift-wood," in the papers of the Swedish Academy.] 151.

[152] [Compare remark by the Hydrographic Office, in the foot-note on page 125.] 152.

Notes.

153-65. [153] Keith Johnston, jr.'s Hand-book of Physical Geography, Edinburgh and London, 1870, p. 117.

154. [154] Findlay, North Atlantic Memoir, London, 1861, p. 345.

155. [155] Compare the memoir of Irminger, page 100 of this volume.

156. [156] Scoresby, Account of the Arctic Regions, Edinburgh, 1820, i, p. 209.

157. [157] Wallich, The North Atlantic Sea-bed, part 1, p. 7.

158. [158] Zeitschrift für Allgemeine Erdkunde, new series, vol. xi, 1861, table 2.

159. [159] Scoresby, Account of the Arctic Regions, p. 187.

160. [160] Geographische Mittheilungen, 1869, pp. 210 and 211. [Compare the table of deep-sea temperatures, note 210.]

161. [161] Wind Charts of the North Atlantic Ocean, printed for the Board of Trade, London.

162. [162] Report of the Committee of the Meteorological Office, by Captain Henry Tôynbee, Marine Superintendent, Meteorological Office. London, 1869, pp. 13 and 14.

163. [163] H. Mohn, Oversigt over Norges Klimatologi, Kristiania, 1870, pp. 34 and 35.

164. [164] The Mean Pressure of the atmosphere and the prevailing winds over the Globe for the months and for the year, by Alexander Buchan, M. A., F. R. S. E., Secretary of the Scottish Meteorological Society, &c. Edinburgh, 1869. (Published also in the Transactions of the Royal Society of Edinburgh, vol. 25.)

165. [165] Nature, April 21, 1870, p. 640.

In the meeting of the Scottish Meteorological Society of March 30, Dr. Keith Johnston read a paper "On the Temperature of the Gulf Stream in the North Atlantic Ocean." He began by saying that he had read a paper on the Gulf Stream at the half-yearly meeting of the Society in January, 1862, which embodied the results of observations made in the Iceland seas by Captain Irminger, of Denmark. That paper attracted the attention of meteorologists, and the result was that new stations had been established by the society in Iceland and the Faroe Islands, each of them supplied with the best instruments placed at the disposal of the council by the Board of Trade. The Meteorological Institute of Norway

Notes.
has, during the past three years, made observations of the temperature of the sea at the light-houses round the coast as far north as latitude 71° 06′ N., and on board ships engaged in the Arctic fisheries. From these observations, together with those made at different stations off the Scottish coast, in Faroe and in Iceland, Professor Mohn of Christiania has just published a memoir on the temperature of this part of the Atlantic, illustrated by five charts for the four seasons of the year. The five charts exhibited were based on Professor Mohn's theory. The singular distribution of the temperature of the sea between Iceland, Scotland, and Norway must, as Mr. Mohn observes, be regarded as the best representation of the course and the extent of the Gulf Stream in these parts. The line designated as the thermal axis indicates the direction of the principal axis of the current. It is along this axis that the warm waters of the Gulf Stream are pushed forward by the current to the latitude of the North Cape and Spitzbergen. At the same time the water is cooled as it advances, either from the effect of latitude or from the loss of heat experienced on both sides in beating the coast of Norway and in melting the ice of the sea between Greenland and Spitzbergen. The distribution of temperature, during the summer months, being dominated by the solar heat, the isotherms of the sea have a greater tendency to follow the parallels of latitude. The thermal axis is, as it were, thrown on the shores of Norway, where it may be followed to the west coast of Spitzbergen and Nova Zembla. The distance of the thermal axis of the Gulf Stream from the west coast of Norway being not more than one hundred and twenty-five miles, its effect on the climate of that country must be very remarkable. Thus we find that the west coast, during winter, has a temperature of the air which surpasses by from 40° to 50° that due to corresponding latitudes, if there were no current of warm water. On the shores of Norway, round to the frontiers of Russia, the current of the sea is directed generally toward the north and east; and, carried by the current to this far northern region, products of the vegetable kingdom are often found which had their origin in the West Indies—a fact which proves beyond all question the existence of a northeastern branch of the Gulf Stream thus far into the Arctic Ocean. 165-66.

Mr. Buchan said that, to illustrate the effect of winds upon the currents, he had looked into the question of the temperature of the air at various stations as compared with that of the sea. Over the whole of Scotland, and as far west at least as the Faroes, the winds were southwest in winter, there being very few easterly or northeasterly winds. In Iceland a different state of things prevailed, the mean direction of the wind being east-northeast. On the west coast of Norway the prevailing wind was uniformly southeast or south-southeast, that is to say, the winds blow to a considerable extent off the land, where, at that season, the temperature is exceedingly low. In summer the winds in Iceland continue easterly, with some northing in them; but in the north of Scotland they prevail more from the west. On the coast of Norway the summer winds take the opposite direction to those prevailing in winter. The same holds good in the south and north of Norway, where the difference was 4° in favor of the sea.

[166] Geographische Mittheilungen, 1867, p. 185. [Compare the extract from Dr. Petermann's memoir "The Northernmost Land of the Globe," note 4, page 201 of this volume.] 166.

Notes.

167-70. [167] A. v. Etzel, Greenland, pp. 109 and 112.

168. [168] Manuscript of Professor Wyville Thomson, LL. D., F. R. S., dated Belfast, 21st May, 1870. Compare also notes 7 and 8, page 222 and seq. of this volume where the observations are discussed.

169. [169] From the same.

170. [170] According to a communication in the Magazine for Foreign Literature, (Literatur the Auslandes,) of May 21, 1870, p. 310, Professor Dove now considers the Gulf Stream to reach only to Norway and Nova Zembla. It is stated there as follows: "Putnam's Magazine, (New York,) in its November and December numbers for 1869, contained two articles entitled 'Gateways to the Pole,' and 'Dumb Guides to the Pole,' in which the well-known theory, advocated also by A. Petermann, of an always-open current surrounding the North Pole, is preached with all the ardor of a propagandist, and which are intended to constitute that hypothesis—although it has never yet been confirmed by practical exploration—a mathematical axiom illustrated by diagrams. We are anxious to learn what Professor Dove, the great German explorer of the currents of the ocean and the air, will say to these articles. In one of the last meetings of the Berlin Geographical Society he expressed as his opinion, founded upon scientific researches, that the influences of the Gulf Stream, as regards temperature, do not reach farther than to the north coast of Norway and to Nova Zembla, and that all that has been said of an always-open sea around the North Pole is fiction."

It is a pity that Professor Dove has not yet published his researches on the currents of the ocean, and especially on the Gulf Stream. Regarding the allusion to me, I have to say that I never have advocated a theory of "an always-open current surrounding the North Pole;" what I do advocate is explained in this memoir. The allusion is, at the best, somewhat unclear and vaguely expressed. In the Geographische Mittheilungen for 1869, p. 35, [Compare note 4, page 201 of this volume.—Hydrographic Office,] I have demonstrated the existence of a warm current discharging north of Behring's Straits into the Arctic Ocean, and have traced it as far as latitude 72° N.; in this memoir I have followed the Gulf Stream to 82⅓° northern latitude, north of Spitzbergen. It is evident that these currents cannot cease abruptly in respectively 72° and 82⅓° north latitude; their further course, however, is not known, and remains to be explored by the North Polar expeditions. That a current from the southward, probably a sub-surface one, rising in places to the surface, may extend to the North Pole, if the latter is oceanic, I deem not at all improbable. No one knows anything certain of the currents north of 82¾°, (Parry's highest point.)

What will these gentlemen say when they read the report of the savans of the late British sounding expedition, (the most important and most successful of all the expeditions thus far,) in which they express, as the result of their researches, their conviction that, in the Irish and Scottish waters, a stream from the North Pole is meeting one coming from the South Pole, executing there, as they sportively say, a whirl-dance? [Compare page 75 of this volume.—Hydrographic Office.]

[171] Letter of Professor Wyville Thomson, dated Belfast, May 21, 1870. This gentleman, one of the savans of the late British sounding expedition, is now preparing for publication a preliminary report upon the results of the expedition, to be followed by a larger book containing all details. Notes. 171-72.

[172] On the composition of sea-water in the different parts of the ocean. (Philosophical Transactions of the Royal Society of London, 1865, part 1, pp. 203 *et seq.*) 172.

[Of this interesting but lengthy paper only the introductory remarks, and the passages bearing upon the Gulf Stream and the waters under its influence, can be reprinted here.—HYDROGRAPHIC OFFICE.]

ON THE COMPOSITION OF SEA WATER IN THE DIFFERENT PARTS OF THE OCEAN. BY GEORG FORCHHAMMER, PROFESSOR AT THE UNIVERSITY AND DIRECTOR OF THE POLYTECHNIC INSTITUTE AT COPENHAGEN.

In the year 1843 a friend of mine, Mr. Ennis, of Falmouth, sent me some bottles of sea water from the Mediterranean, which I subjected to a chemical examination, a work which induced me to collect what other chemists had determined about the constitution of the water of the great Ocean. This labor convinced me that our knowledge of the composition of sea-water was very deficient, and that we knew very little about the differences in composition which occur in different parts of the sea.

I entered into this labor more as a geologist than as a chemist, wishing principally to find facts which could serve as a basis for the explanation of those effects that have taken place at the formation of those voluminous beds which once were deposited at the bottom of the ocean. I thought that it was absolutely necessary to know with precision the composition of the water of the present ocean, in order to form an opinion about the action of that ocean from which the mountain limestone, the oolite, and the chalk with its flint, have been deposited, in the same way as it has been of the most material influence upon science to know the chemical actions of the present volcanos, in order to determine the causes which have acted in forming the older plutonic and many of the metamorphic rocks. Thus I determined to undertake a series of investigations upon the composition of the water of the ocean and of its large inlets and bays, and ever since that time I have assiduously collected and analyzed water from the different parts of the sea. It is evident that it was impossible to collect this material in a short time and without the assistance of many friends of science, and I most gratefully acknowledge how much I am indebted to many distinguished officers of the Danish and British navy, as well as to many private men, who were all willing to undertake the trouble carefully to collect samples of sea-water from different parts of the ocean, both from the surface and from different depths. I shall afterward, when giving the particular analyses, find an opportunity to mention the name of each of those to whom I am indebted for my material.

While I was thus occupied for a space of about twenty years, another series of experiments, closely allied to my work, was commenced in England, and has partly been published, under the able and scientific superintendence of Rear-Admiral Fitz Roy. This most important series of observations regards the spe-

Note.
172. (Con'd.) cific gravity of sea-water from the most different parts of the globe; it comprehends a much more numerous series than my observations; but I trust that it will not make my work superfluous, but that both these investigations will supplement each other. By the kindness of Admiral Fitz Roy, I am able to compare the instruments, which are used by the British navy, with my chemical analyses, and thus to obtain a comparison between both series.

I have, at different times, found an opportunity to publish several parts of my observations, and in 1857 I collected what had been done up to that time in an academical treatise in the Danish language. Since that time I have obtained numerous samples of sea-water, principally from places which my previous examination had not reached. In this new form, and greatly augmented by new facts, I permit myself to lay it before the illustrious scientific society of a nation to whose navigators I owe so great a part of the material for my inquiries. This part contains an enumeration of the elements which hitherto have been ascertained to exist in the water of the ocean, and an explanation of the methods used to show their presence and to determine their quantity. It contains a determination, as complete as possible, of the distribution of the saline substances at the surface of the different parts of the sea, and in the different depths at the same place.

On the Elements which occur in the Water of the Ocean.

The elements which occur in the greatest quantity in sea-water have been long known, and chlorine, sulphuric acid, soda, magnesia, and lime have, for more than a century past, been considered as its essential parts. In our century iodine, bromine, potash, silica, phosphoric acid, and iron have been discovered in sea-water, and the latest inquiries, my own included, have brought the number of elements occurring in sea-water up to twenty-seven.

Next to direct analyses of sea-water, the analysis of sea-weeds and of animals living in the sea offers us precious means of determining those elements which occur in so small a quantity in sea-water that it hitherto has been impossible to ascertain their presence in the water by chemical tests. It is now well known that the organic beings collect substances which are necessary for their existence, and thus offer the means to the chemist of ascertaining that these substances were present in the medium in which the organisms lived, and from which they collected their food. As to the plants of the sea, the whole fucoid tribe derive the substances of which they consist from the surrounding sea-water and from the air with which they are in contact, but not from the soil on the bottom of the sea, since that part of them which is generally called their root is no root at all, and is not qualified to extract food from the soil and stones to which it adheres. Even those marine plants which do not belong to the fucoid tribe, as, for instance, the *Zostera marina*, and which have a real root that may extract food from the soil, will most probably extract the great quantity of mineral elements which they contain mostly from the surrounding sea-water. As to the animals which live in the sea, they derive their substance either from the sea-water itself, or from plants that are nourished by sea-water, or from other animals that live upon sea-weeds, thus deriving their whole mineral substance either directly or indirectly from the sea. I have availed myself of the means which the organisms of the sea furnish to determine a great number of elements that thus must exist in solution in sea-water.

As to this great number of elements contained in the sea-water, we might ask one question which is of great importance for the history of the earth, viz, how all these elements got into the sea, whether they were in the original sea, or subsequently got into the sea, where they are now slowly accumulating. When we consider that the sea constantly loses a great quantity of pure water by evaporation, and that a large part of this water falls on the land, dissolves a number of substances from it and carries them at last into the sea, where they constantly would increase in quantity if it were not for its organisms which deprive it again of them, we may well suppose that these two effects, of which the one acts to increase and the other to diminish the quantity of mineral substances in sea-water, are pretty equal, and leave the sea unchanged. I will, however, not dwell upon these mutual chemical decompositions and combinations which, partly depending upon organic life, partly upon inorganic mechanical and chemical forces, play such a great part in the changes of the earth; but I hope, at some future time, to find leisure to publish my investigations in this branch of the history of the earth. **Note. 172.** (Con'd.)

The elements which hitherto have been found in sea-water are: 1, oxygen; 2, hydrogen; 3, chlorine; 4, bromine; 5, iodine; 6, fluorine; 7, sulphur; 8, phosphorus; 9, nitrogen; 10, carbon; 11, silicium; 12, boron; 13, silver; 14, copper; 15, lead; 16, zinc; 17, cobalt; 18, nickel; 19, iron; 20, manganese; 21, aluminium; 22, magnesium; 23, calcium; 24, strontium; 25, baryta; 26, sodium; 27, potassium.

[In enumerating the above elements, the author discusses also their status as components of the sea water, and explains more or less minutely the manner of their detection in it. He then devotes a chapter to the "Quantitative Analysis of Sea Water," and proceeds as follows:—Hydrographic Office.]

On the Distribution of the Salts in the Different Parts of the Sea.

The next question to be considered refers to the proportion between all the salts together and the water; or, to express it in one word, I may allow myself to call it the salinity of the sea-water, and in connection with this salinity or strength, the proportion of the different solid constituent parts among themselves. On comparing the older chemical analyses of sea-water we should be led to suppose that the water in the different seas had, besides its salinity, its own peculiar character expressed by the different proportions of its most prevalent acids and bases, but the following researches will show that this difference is very trifling in the ocean, and has a more decided character only near the shores, in the bays of the sea, and at the mouth of great rivers, wherever the influence of the land is prevailing.

In the tables which are annexed to this paper I have always calculated the single substances and the whole quantity of salt for 1,000 parts of sea-water; but besides this I have calculated the proportion between the different substances determined, referred to chlorine =100, and of all the salts likewise referred to chlorine. This last number is found, if we divide the sum of all the salts found in 1,000 parts of any sea-water, by the quantity of chlorine found in it, and I call it the coefficient of that sample of sea-water. The following remarks, and the tables which belong to them, will show that there is a very small difference in the coefficient of the different parts of the ocean, but that the differences become striking in the neighborhood of the shores.

Note.
172. A. *On the Salinity of the Surface of the different parts of the Ocean and its Inlets.*
(Con'd.)

In the tables annexed to this paper I have divided the sea into seventeen regions. My reason for doing so was that by this method I was able to avoid the prevailing influence which those parts of the ocean which are best known, and from which I have most observations, would exert upon the calculations of the mean number for the whole ocean.

First Region. The Atlantic Ocean between the Equator and 30° N. Latitude.—The mean of fourteen complete analyses is 36.169 per 1,000 salt; the maximum is 37.908 per 1,000; the minimum, 34.283. The maximum lies in 24° 13′ N. latitude, and 23° 11′ W. longitude, about 5° W. from the coast of Africa, where no rivers of any size carry water from the land, and where the influence of the dry and hot winds of the Sahara is prevailing. The maximum for the region is also the maximum of surface-water for the whole Atlantic; it is equal to the mean salinity of the Mediterranean, and only the maximum of that sea off the Libyan desert and that of the Red Sea are higher. The minimum is from 4° 10′ S. latitude, and 5° 36′ W. longitude, close to the coast of Africa, where the large masses of fresh water which the great rivers of that region pour into the ocean exercise their influence. Its coefficient is 1.810.

Second Region. The Atlantic Ocean between 30° N. Latitude, and a line from the North Point of Scotland to the North Point of Newfoundland.—The mean of twenty-four complete analyses is 35.946 salt; the maximum, 36.927; and the minimum 33.854. The maximum is in 38° 18′ N. latitude, and 43° 14′ W. longitude in the middle of the Atlantic; the minimum occurs in 43° 26′ N. latitude, and 44° 19′ W. longitude, and is evidently owing to the enormous quantity of fresh water which the St. Lawrence, through its southern mouth, pours into the Atlantic. This region is under the influence of the Gulf Stream, and the corresponding South Atlantic region has only a mean salinity of 35.038. Its coefficient is 1.812.

Third Region. The Northern Part of the Atlantic, between the Northern Boundary of the Second Region, and a line from the Southwest Cape of Iceland to Sandwich Bay in Labrador.—The mean salinity deduced from twelve complete analyses is 35.391; its maximum, 36.480; its minimum, 34.831. The maximum falls into 55° 45′ N. latitude, and 20° 30′ W. longitude, just on the boundary of the second region; the minimum in 60° 25′ latitude, and 3° 15′ W. longitude, near the large northerly opening of the North Sea. This region owes evidently its high salinity to the large northern direct branch of the Gulf Stream. Its coefficient is 1.808.

Fourth Region. This region comprehends the East Greenland current, which flows along the east coast of Greenland toward the south and west, turns toward the north when it reaches the south promontory of Greenland, runs along the west coast of that large land into Davis' Strait, where it disappears in the Polar Current from Baffin's Bay.—I owe most of the samples from this current to Colonel Schaffner, who took them on his expedition to Iceland and Greenland, connected with the Northern Transatlantic Telegraph. The quantities being too small to allow a complete analysis, I have only determined the quantities of chlorine and sulphuric acid. I have, however, analyzed three other samples of water from this current taken by Captain Gram, who during many years commanded one of the Danish government's Greenland ships; and from these three complete analyses I have deduced the coefficient 1.813, instead of 1:812, which is the mean coefficient of the whole ocean. Thus I have calculated the mean salinity of the East Greenland current to be 35.278, while it is in the third region 35.391, and in the sea between Norway and Spitzbergen 35.347. These observations about the salinity of the current, connected with some other observations which will be afterward discussed, make it highly probable that the East Greenland current is the returning Gulf Stream. At all events it is no polar current, which will easily be seen in comparing it with the Baffin's Bay current with a salinity of 33.281, or the water to the north of Spitzbergen with 33.623, or the Patagonian polar current which runs along the west coast of South America, and has 33.966. Nor is it probable that it comes from the north shores of Siberia, where such a great number of powerful rivers bring a vast quantity of fresh water into the sea. Its salinity is so great that it even exceeds that of the South Atlantic region, between 30° S. latitude and the line between the Cape of Good Hope and Cape Horn, whose salinity is only 35.038. Note. 172. (Con'd.)

Fifth Region, A. The Baffin's Bay and Davis' Straits Region.—The mean of eight complete analyses is 33.281; the maximum 34.414; the minimum 32.304. This region shows the very interesting fact that its salinity increases on passing from latitude 64° toward the north, being in 64°, 32.926; in 67°, 33.187; somewhat further to the north 33.446; and in latitude 69° 33.598. This peculiarity is owing to the powerful current from the Parry Islands, which through different sounds passes into Baffin's Bay, where it is mixed with the great quantity of fresh water that comes into the sea from the West Greenland glaciers. Had this fact been known before the sounds that connect the Parry Archipealgo with Baffin's Bay were discovered, it might have proved the existence of these sounds, because bays and inlets show quite the reverse; the further we get into them the less saline the water becomes.

Fifth Region, B. The Polar Sea between the North Cape in Norway and Spitzbergen.—I have eleven samples of water taken on the Swedish Spitzbergen expedition by Professors Nordenskiöld and Blomstrand, of which I have rejected one taken in one of the bays of Spitzbergen, and another belonging to the sea to the north of Spitzbergen. None of these analyses were complete, and I have only determined the quantity of chlorine and sulphuric acid; and even the latter could in several instances not be determined, since the water had fermented. The mean quantity of chlorine in the nine remaining samples was 19.507; and if we take the mean coefficient of the four North Atlantic regions, (the East Greenland current included,) 1.810, 1.812, 1.808, and 1.813, it will be 1.811; and if we use this coefficient, the mean salinity of that part of the sea will be 35.327; or if we take the mean coefficient of the whole ocean, 1.812, it will be 35.347. The maximum was in 76° 15′ N. latitude and 13° 15′ E. longitude, with 20.019 chlorine = 36.254 salt; the minimum in 70° 30′ N. latitude and 19° 05′ E. longitude, with 18.993 chlorine = 34.396 near the coast of Norway, which evidently has had influence upon the result.

Fifth Region, C. The Polar Sea to the north of Spitzbergen.—I have only one observation, of which I owe the sample to Professor Blomstrand. It is from 80° N. latitude and 12° E. longitude, containing 18.517 chlorine, which gives, with a coefficient 1.812, a salinity of 33.623.

Sixth Region. The German Ocean, or the North Sea.—The mean of six complete analyses is 32.823 per 1,000 salt; the maximum is 35.041; the minimum, 30.530

Note. 172. (Con'd.) per 1,000 salt. The maximum is from the mouth of the channel near the Gallopper, and the minimum is from Heligoland, where the water of the Elbe has a considerable influence. The mean coefficient is 1.816, which also shows the influence of the land.

Seventh Region. The Kattegat and the Sound.—The quantity of salt in the water of this region is very variable; a northerly current and wind bring water which is richer in salt than that brought by a southerly current and wind. The mean of six complete analyses and 141 observations, in which only the chlorine was determined, gives 16.230 per 1,000 salt, the maximum 23.243, and the minimum 10.869. It must further be remarked that the proportion of chlorine and lime, which in the whole ocean are in mean number 100:2.96, in this region are 100:3.29, which again must be considered as depending upon the influence of the land. The mean coefficient is 1.814.

Eighth Region. The Baltic.—The mean numbers are deduced from complete analyses of samples of sea-water taken on board the frigate Bellona, on a voyage from Copenhagen to St. Petersburg, combined with a complete analysis of water from Svartklubben to the north of Stockholm. Its salinity varies very much in the different localities, and is of course less in the eastern than in the western portions of the Baltic; it varies also in the same place, according to wind and current. I found the mean for this region 4.931 per 1,000 salt; the maximum 7.481 in the channel between Bornholm and Sweden; the minimum, in the merchant harbor of Kronstadt, = 0.610 per 1,000 salt. The mean proportion of chlorine and lime is 100:3.64; in the Bay of Finland it is 100:7.49. The mean coefficient is 1.835; in the merchant harbor of Kronstadt it is 2.230. The influence of the land is here expressed in these different numbers.

Ninth Region. The Mediterranean.—All my observations lie between the Straits of Gibraltar and the Greek Archipelago. It is a general belief that the water of the Mediterranean contains more salt than the water of the ocean in general; and this opinion depends partly upon some analyses, partly upon the observation that, at the Straits of Gibraltar, there is a constant upper-current which runs into the Mediterranean, and an under-current which carries its waters into the Atlantic. This opinion of the superior salinity of the Mediterranean has been completely confirmed by eleven complete analyses of water taken between the Straits of Gibraltar and the Greek Archipelago.

The mean salinity of this region is 37.936, while the whole ocean contains 34.388 per 1,000 salt. Its coefficient is 1.815. Its maximum (39.257) falls between the Island of Candia and the African shore off the Libyan Desert, as the maximum of the Atlantic is off the Sahara; but the mean of the Mediterranean is a little higher than the maximum of the Atlantic. The whole Mediterranean is under the influence of Africa and its hot and dry winds.

The minimum for the Mediterranean is at the Straits of Gibraltar, with 36.301; the mean salinity of the Northern Atlantic Ocean, between 30° and 40° N. latitude, but more toward the west, is 36.332, (deduced from eight complete analyses;) the surface water from the Straits of Gibraltar is thus corresponding to that from the Atlantic of the same latitude.

When entering the Straits the quantity of salt increases rather rapidly, and is at a short distance from them, at 4° 02′ W. longitude, 37.014; between the Balearic Islands and the Spanish coast it is 38.058, and a little further on

38.321; between the Island of Sardinia and Naples, 38.654. Somewhat nearer to the coast of Malta it decreases to 38.541, and further on toward Greece it decreases again to 38.013, and would probably decrease more in the direction of the Bosphorus, but I have no observations from that part of the Mediterranean. From Malta to the coast of Africa it increases to the maximum of 39.257. **Note. 172.** (Con'd.)

There is another opinion generally reported, that the water of the Mediterranean contains a greater proportion of magnesia than the water of the ocean. This is, however, not the case; the mean proportion between chlorine and magnesia is for the Mediterranean 100:10.90, and for the ocean, 100:11.07; nor is there any remarkable difference in the proportions of the other main substances. The proportion between chlorine and sulphuric acid is for the ocean 100:11.89, and for the Mediterranean, 100:11.82; for lime it is in the ocean 100:2.96, and in the Mediterranean 100:3.08.

Tenth Region, A. The Black Sea and the Sea of Azov.—Like the Baltic, the Black Sea contains sea-water of but little strength, and the mean deduced from three observations, of which one is from myself, the two others by M. Göbel, is 15.894; maximum, =18.146; minimum, =11.880. In my own analysis of water from the Black Sea, fifty English miles from the Bosphorus, I found the proportion of chlorine 100, to sulphuric acid 11.71, to lime 4.22, to magnesia 12.64, and thus a considerable increase in the lime and magnesia.

[The other regions being beyond the supposed influence of the Gulf Stream, they will here only be enumerated with their mean, maximum, and minimum of salinity, as follows:

Tenth Region, B. The Caspian Sea, from five analyses by Mr. Mahner, showing great differences in the quantity of saline matter, between 56.814 and 6.236 per 1,000. Its mean coefficient is 2.434.

Eleventh Region. The Atlantic Ocean between the Equator and 30° S. latitude.—Mean quantity of salt 36.553; maximum 37.155; minimum 35.930; mean coefficient 1.814.

Twelfth Region. The Atlantic Ocean between 30° S. latitude and a line from Cape Horn to the Cape of Good Hope.—Mean salinity 35.038; maximum 35.907; minimum 34.151; mean coefficient 1.808.

Thirteenth Region. The Sea between Africa and the East Indian Islands.—Mean 33.868; maximum 35.802; minimum (in the Bay of Bengal) 25.879; mean coefficient 1.814.

Fourteenth Region. The Sea between the southeast coast of Asia, the East Indian Islands, and the Aleutian Islands.—Mean 33.506; maximum 34.234; minimum 32.370; mean coefficient 1.815.

Fifteenth Region. The Sea between the Aleutian Islands and the Society Islands, between 38° N. latitude and 32° S. latitude.—Mean 35.219; maximum 36.061; minimum 34.157; mean coefficient 1.806.

Sixteenth Region. The Patagonian Cold-Water Current.—Mean 33.966; maximum 34.152; minimum 33.788; mean coefficient 1.806.

Seventeenth Region. The South Polar Sea.—In regard to this region the author makes the following interesting remarks:—HYDROGRAPHIC OFFICE.]

I have only three analyses, all on samples taken by the late Sir James Ross. One was from 77° 32′ S. latitude, 188° 21′ E. longitude, close to the great ice-barrier. The water was full of animalculæ, but, notwithstanding, had not fermented. The quantity of salt which it contained was 28.565 per 1,000. The next sample was from 74° 15′ S. latitude, 167° E. longitude; the water was muddy, probably from animalculæ and diatomaceæ. The place was not far from Victoria Land, at some distance from Coulman Island. It contained only 15.598 salt. The third, from 65° 57′ S. latitude, 164° 37′ E. longitude, had the surprising quantity of salt 37.513 per 1,000. The mean of these three observations is 27.225 per 1,000; but this mean number is of very little consequence, being derived from numbers differing so greatly. It is, however, very surpris-

Note.
172. (Con'd.) ing that water from the neighborhood of the supposed Antarctic continent should have a salinity higher than any one found in the south equatorial regions of the Atlantic, and only be exceeded by a single one in the North Atlantic regions. I am sure that no material fault exists in the analyses, and this curious fact must thus remain unexplained until repeated observations in that region shall procure us further information. Should the observation prove to be correct it would render the existence of a "Gulf Stream" in the Antarctic zone very probable.

There is still another peculiarity in these observations which deserves attention, viz, the great proportion of sulphuric acid to chlorine. In the water in the neighborhood of Coulman's Island it is 12.47:100, and in that from 65° 57′ S. latitude 12.55:100, while in the whole ocean it is as 11.89:100. This might depend upon the very pronounced volcanic character of the Antarctic continent.

There is still one question to be discussed with respect to the Antarctic Sea—how it is to enter into the mean numbers of the whole ocean. The observation from the neighborhood of Coulman's Island must be rejected, because it is too near the land, and we have no corresponding observations from the open Antarctic Ocean. Its high coefficient, 1.861, shows the great influence of the neighboring land. The observation from 65° 57′ S. latitude must also be rejected as doubtful; there remains only the observation from the neighborhood of the great ice-barrier, and I have taken that for the mean of the Antarctic region.

General Results of the Preceding Investigation.

If we except the North Sea, the Kattegat, Sound, and Baltic, the Mediterranean and Black Sea, the Caribbean and the Red Sea, which have all the characters of bays of the great ocean, the mean numbers are the following:

Sea-water.	Chlorine.	Sulphuric acid.	Lime.	Magnesia.	All salts.	Coefficient.
1,000	18.999	2.258	0.556	2.096	34.404	1.812
....	100.	11. 88	2. 93	11. 03	....	....
Equivalents...	429.	45.	16.	82.	....	....

Thus it is evident that sea-water in its totality is as little a chemical compound as the atmospheric air; that it is composed of solutions of different chemical compounds; that it is neutral, because it everywhere in the atmosphere finds carbonic acid to neutralize its bases, and everywhere on its bottom and shores finds carbonate of lime to neutralize any prevailing strong acid; that, lastly, the great stability of its composition depends upon its enormous mass and its constant motion, which occasions that any local variation is evanescent compared to the whole quantity of salt.

If we take the mean numbers for the five regions of the Atlantic, between the southernmost point of Greenland and that of South America, we find the mean quantity of salt for the whole Atlantic 35.833, while the sea between Africa and the East Indies has only 33.850; the sea between the East Indies and the Aleutic Islands, 33.569; and the South Sea, between the Aleutic Islands and the Society Islands, 35.219 per 1,000 salt. The Atlantic is thus that part of the ocean which contains the greatest proportion of salt, which result is rather surprising if we consider the vast quantity of fresh water which the rivers of

Africa, America, and Europe pour into it: of Africa four-fifths are drained into the Atlantic either directly or through the Mediterranean; it is most probably nine-tenths of America which is drained into the Atlantic, since the Cordilleras run close to the western shore of the continent; and of Europe, also, about nine-tenths of its surface sends its superfluous water to the Atlantic. This greater quantity of fresh water from the land, and the greater quantity of salts in the corresponding sea, seem to contradict each other, but can be explained by a higher temperature, and, as the result of this higher temperature, a greater evaporation. **Note. 172.** (Con'd.)

Some of the large bays of the ocean have in the tropical or sub-tropical zone a greater mean than the Atlantic. Such are the Mediterranean, with 37.936 per 1,000 salt, (mean of eleven observations); the Caribbean Sea, with 36.104 per 1,000, (one observation); the Red Sea, 43.067 per 1,000, (mean of two but little differing observations,) which is the greatest salinity of the sea I know of.

In approaching the shores the sea-water becomes less rich in salts, a fact which finds its explanation in the more or less great quantity of fresh water which runs into the sea. On such shores, where only small rivers flow out, the effect produced is but very trifling, as, for instance, on the western shores of South America. The effect of large rivers in diluting the sea-water is much greater than is generally supposed; thus, the effect of the La Platte River, whose mouth lies in about 35° of south latitude, was still observable in a sample of sea-water taken at 50° 31′ S. latitude, at a distance of 15° of latitude, or 900 English miles from the mouth of the river; at about the same distance the water of the North Atlantic Sea suffered a considerable depression in salinity, probably owing to the water of the St. Lawrence. This influence is of a double kind, partly in diluting the sea-water, partly in mixing it up with organic substances that will occasion its decomposition by putrefaction.

The Polar currents contain less salt than the Equatorial. I have determined the quantity and nature of the salts in two very well defined Polar currents—the West Greenland Polar current, with 33.176 per 1,000 salt, and the Antarctic Polar or Patagonian current, on the west side of South America, which contains 33.966. It is highly interesting to observe that the East Greenland current, which, according to its geographical relations, might be considered as a Polar current, which, in fact, has been considered in that way, has a very high mean quantity of salt, viz, 35.278 per 1,000, while the sea to the north of Spitzbergen, according to one analysis, contains 33.623 per 1,000 salt. I think I shall afterward, from other phenomena also, prove that the East Greenland current is a returning branch of the Gulf Stream; but I may here remark that the great quantity of salt which it contains, almost by itself proves the more equatorial nature of this current.

[After some remarks as to the chemical substances which constitute the salts of the sea-water the author proceeds to discuss:—HYDROGRAPHIC OFFICE.]

B. *On the Difference of the Contents of Sea-Water at the surface and in different depths.*

It would be natural to suppose that the quantity of salts in sea-water would increase with the depth, as it seems quite reasonable that the specific gravity of sea-water would cause such an arrangement. But this difference in specific

Note. 172. (Con'd.) gravity, relative to the increase in the quantity of salts, is counteracted by the decreasing temperature from the surface to the bottom. We have parts of the sea where the quantity of solid salts increases with the depth; in other parts it decreases with the increasing depth; in other places hardly any difference can be found between surface and depth; and lastly, I have found one instance where water of a certain depth contained more salt than both, that above and below. These differences are, to a great extent, dependent upon currents, both on the surface and in different depths.

The phenomenon of double currents at the Straits of Gibraltar has been long known, and in close connection with these double currents the saline contents of the water of the Mediterranean increase in quantity with the depth. There is, however, one exception in the Mediterranean, under interesting circumstances, which I shall afterward discuss more at length. I have made eleven complete analyses of the surface-water of the Mediterranean, and calculated another, quoted in Violette et Archambault, "Dictionaire des Analyses Chimiques," vol. 1, p. 358, without a more exact reference to the place where it was taken. Of my own analyses, one must be rejected on account of the great quantity of sulphureted hydrogen that had been formed, and of course caused a loss of sulphuric acid; but it causes also a loss of lime, because the formation of sulphureted hydrogen is contemporaneous with the formation of carbonic acid, which will precipitate the lime when deprived of its sulphuric acid. The mean number of the remaining analyses of surface-water is 20.889 per 1,000 for the chlorine, and 37.936 for all salts. The mean number for chlorine of eight analyses of water taken from a depth of between 300 to 600 feet is 21.138. In each case the deep water was richer in chlorine than that from the surface, except in one instance, where the chlorine of the surface-water was 21.718, and all salts, calculated from a complete analysis, were 39.257 per 1,000, while the chlorine of water taken from a depth of 522 feet was 21.521 per 1,000. This curious exception occurred between Candia and the African coast, where the dry and hot winds from the neighboring Libyan Desert evidently causes a strong evaporation and a considerable elevation of temperature, which counteract each other as to specific gravity. The difference between the upper and lower current in the Straits of Gibraltar is, in the surface-water, chlorine, 20.160 per 1,000, all salts, 36.391, and in the depth of 540 feet, chlorine, 20.330.

The cause why the surface-current is Atlantic water flowing into the Mediterranean, and the under-current Mediterranean water flowing into the Atlantic, has long since been assigned to depend upon the comparatively small quantity of water that flows from the land into the Mediterranean, and the hot and dry African winds that cause more water to evaporate than the rivers bring into the sea. My analyses have not given me any reason to alter anything in our views of the cause of this difference, nor do I regard the single instance of water that is more rich in salts at the surface than in the depth as more than a local exception.

As to the difference between surface and deep water for other substances, I shall only remark that the deep water of the Mediterranean contains a remarkable excess of sulphuric acid. The proportion between chlorine and sulphuric acid is—

Note. 172. (Con'd.)

For the whole ocean..100 : 11.89
Mediterranean surface......................................100 : 11.82
Mediterranean depth..100 : 12.07

Already in the Straits of Gibraltar the difference has the same character. The proportion is—

For the surface..100 : 11.42
For the deep water...100 : 11.93

In some places, however, in the Mediterranean the surface-water is richer in sulphuric acid than water from the depth; thus, for instance, the sea between Sardinia and Naples had a proportion of 12.55 sulphuric acid in surface-water.

In the Baltic we have the same phenomenon; the water from the depth contains likewise more salt than that from the surface, but the direction of the currents is the reverse. The upper-current goes generally (not always) out of the Baltic, and the under-current goes, as it would appear, always into the Baltic. The cause of this great difference between the Baltic and the Mediterranean is evident; the Baltic receives the excess of atmospheric water from a great part of Europe. The greater part of Sweden, the greater part of European Russia, and a great part of North Germany send their water into the Baltic, and the evaporation is comparatively small. Thus the excess must find its way through the Sound and the Belts.

[The author now explains in detail the manner and the results of the observations made in the Baltic, (at Elsinore, Copenhagen, Kiel, near Stockholm, and in the Bay of Finland,) and then proceeds:—Hydrographic Office.]

Going on now to the main section of the ocean, we will begin with the Atlantic, about which we have the best information, and which seems to show the most interesting facts. I will state the results of my investigations in moving from Baffin's Bay toward the south. In Baffin's Bay itself the water of the surface contains the same quantity of salt as that of the depth; but as soon as we pass the southernmost point of Greenland, the water of the surface contains more salt than that from the depth. This difference increases in going toward the Equator, and is indeed very considerable near that line. About the Equator, and a little to the south of it, many irregularities appear, as, for intsance, in one case where the strongest water was found between two weaker portions above and below. In other cases the quantity of salt decreased with the depth, and in some instances it increased with it.

I shall now state the observations themselves. Dr. Rink sent me water from the surface in Baffin's Bay to the west of Disco Island, which contained 33.594 per 1,000 salt; and at the same place, from a depth of 420 feet, which contained 33.607. The difference is so small that it signifies nothing. At the southernmost point of Greenland a small difference is observed, viz, in 59° 45′ N. latitude, and 39° 04′ W. longitude, where the surface-water contained 35.067, and that from a depth of 270 feet, 34.963; but in about the same latitude, and about 13° further toward W., at 59° 42′ N. latitude, and 51° 20′ W. longitude, the proportion was reversed: the surface-water contained 34.876 per 1,000 salt, while that from the depth contained 34.975 per 1,000.

From the sea between Iceland and Greenland (in which it appears that a returning branch of the Gulf Stream—the East Greenland current—runs

Note. 172. (Con'd.) toward the S. W.) I have obtained eight specimens, from a depth between 1,200–1,800 feet. Unfortunately, no specimens of water from the surface were taken at the same time, but we have a sufficient number of other surface-observations, and thus we may compare the mean numbers, which are 35.356 for the surface, and 35.057 for a depth between 1,200–1,800 feet. In comparing the single observations of the deep water, we find that it contains the greatest quantity of salt in the eastern part, at 35° 01′ W. longitude, with 35.179 per 1,000 salt, decreasing regularly toward the westernmost part of this region, in 55° 40′ W. longitude, with a quantity of salt, =34.858 per 1,000. Specimens taken by Captain Gram, in 59° 50′ N. latitude, and 7° 52′ W. longitude, contained for surface-water, 35.576 for 1,000, and for water from 270 feet depth, 35.462.

I have two other comparative analyses of water from the East Greenland current, of which I owe the specimens to Colonel Schaffner. The analyses were not made complete, but only chlorine and sulphuric acid were determined, which gives at 64° 30′ N. latitude, and 26° 24′ W. longitude, for the surface, 19.616 chlorine, which with a coefficient 1.812 is = 35.544 salt; for a depth of 1,020 feet, 19.504 chlorine, which with a coefficient 1.812 is = 35.341 salt.

The next analysis of water from 62° 47′ N. latitude, and 37° 31′.5 W. longitude, gave for the surface 19.491 chlorine = 35.318 per 1,000 salt; for a depth of 1,200 feet, 19.466 chlorine = 35.272 per 1,000 salt.

Farther to the S. W., near the bank of Newfoundland, specimens taken by Captain Von Dockum gave, for the surface, 36.360 per 1,000 salt; for a depth of 240 feet, 36.598 per 1,000 salt, which is an increasing quantity of salt for the deep water, and coincides with other observations which show that this curious decreasing of the quantity of salt, with the increasing depth, belongs only to the deep part of the Atlantic far from the shores. On the European side of that ocean three samples, taken by Captain Schulz at 47° 15′ N. latitude, and 9° 30′ W. longitude, gave the following quantities of salt: from the surface, 35.922 per 1,000; from a depth of 390 feet, 35.925 per 1,000; from a depth of 510 feet, 36.033 per 1,000; thus showing a trifling increase of salt with the depth.

The most complete set of experiments showing this influence of the shores I have made on twelve samples taken by the Porcupine in 1862, which I owe to the obliging kindness of Rear-Admiral Fitz Roy. The samples are taken between 50° 56′ and 55° 22′ N. latitude, and 12° 06′ and 15° 59′ W. longitude, about four degrees to eight degrees of longitude to the west of Ireland, and five of them were from the surface, while seven were from deep water, between 1,200 and 10,500 feet.

The mean of the five surface observations is—

Chlorine.	Sulphuric acid.	Lime.	Potash.	Magnesia.	All salts.
19.662	2.342	0.566	0.367	2.205	35.613.

The mean of the seven observations from the deep sea is—

Chlorine.	Sulphuric acid.	Lime.	Potash.	Magnesia.	All salts.
19.677	2.357	0.583	0.363	2.193	35.687

Chlorine = 100, the proportions are—

	Chlorine.	Sulphuric acid.	Lime.	Potash.	Magnesia.	All salts.
For surface:	100	11.91	2.88	1.87	11.21	181.1
For deep water:	100	11.98	2.96	1.84	11.14	181.4

The difference is very trifling, and the quantities of salts increase in a very slight degree with the depth. Note. 172. (Con'd.)

[Now follow a number of analyses from more southern parts of the Atlantic, and from the other oceans, after which the author sums up as follows:—HYDROGRAPHIC OFFICE.]

It appears thus that the water of the North Atlantic Ocean, between the southernmost part of Greenland and the Equator, decreases in salinity with the depth, but that this curious fact is observed only in the middle bed of the Atlantic, and disappears when we approach the shores on both sides of the ocean. As to the cause of this rather surprising state, I am still of the same opinion which I expressed when I first observed it, that it depends upon a polar under-current. The hypothesis has been published, that it depended upon fresh-water springs at the bottom of the ocean, and such an opinion might have some chance as long as we only had few observations; but now we have such a number of observations spread over a vast extent of the ocean, that it appears to be quite impossible to explain it by springs of fresh water, which of course must be more frequent and more powerful near the land from which they have their origin. Observation, however, shows the reverse; near the shores the water is either uniform throughout its whole depth, or the quantity of salt increases with the depth.

The Principal Currents of the Atlantic: the Equatorial Current, the Gulf Stream, and the East Greenland Current.

These three currents are, in fact, only the same; they begin, as is well known, in the Bay of Benin, under the Equator, and the main current runs straight to the west over the Atlantic to Cape Roque, on the east coast of South America. I certainly shall not try to lessen the weight of the arguments which assign the cause of this Equatorial current to the rotary motion of the earth, but I will only give some remarks as to other influences that act to the same effect.

If we compare the quantity of salt which is found in sea-water in the region between 5° N. latitude and 5° S. latitude with those between 5° and 20° to the north and 5° and 30° to the south, we find the interesting fact that the water flowing in the vicinity of the Equator contains less salt than that which flows both to the north and to the south of it. For the Equatorial region (5° S. to 5° N.) the mean of six observations is 35.575 per 1,000; or, if we leave out a sample from Sir James Ross, from 150 fathoms depth, (that from the surface is wanting,) it is 35.520. From 5° to 20° N. the mean of eight analyses is 36.279, and from 5° to 30° S. the mean of six analyses is 36.631 per 1,000. This difference is still more striking on comparing the salinity of the Equatorial region with that of the Northern Atlantic region, (second region,) whose mean is 35.932 per 1,000 salt. It deserves, further, attention that the maximum of the Equatorial region is below the mean of its neighbors, both to the south and to the north. It appears to me that this curious fact can be explained only by the vast quantity of fresh water which the Niger, the Ogaway, and a number of other West African rivers carry in this region into the sea, which all gets into the Equatorial current, and moves to the westward. It is evident that this warm water must increase its relative quantity of salt by evaporation during its motion

Note. 172. (Con'd.) across the Atlantic, and a comparison of the analyses of the single samples of the water from the Equatorial current shows that this effect really takes place. The easternmost sample contains the minimum, with 34.238 per 1,000, and the two westernmost samples contain the greatest quantity of salt, with 36.084. Thus the Equatorial current appears as a continuation of the large West African rivers of the Equatorial zone, which dilute the sea-water of the Equatorial region with about 8 per cent. of fresh water, and thus counteract the great evaporation. While the Equatorial current continues its course along the northeast coast of South America, it receives and carries with it the waters of the Paranahyba, the Araguai, the Amazon River, the Essequibo, the Orinoco, and numerous smaller rivers of the north coast of South America; but though I have no observations from this part of the current, the fact is shown by three observations from the sea in the neighborhood of the Danish islands of St. Croix and St. Thomas, whose mean salinity is 35.7 per 1,000; while two degrees more to the north the mean of two observations is 36.7, which seems to be the normal salinity of the West Indian Sea. In the Caribbean Sea, where the Magdalene River gives a new quantity of fresh water, the sea contains on the surface, according to one observation, 36.104 per 1,000 salt. I have unfortunately no observations from the Mexican Gulf, nor from the beginning of the Gulf Stream, where it leaves the Mexican Gulf, but to the north of the Bermudas it contains only 35.883 per 1,000 salt—about the same quantity which the Equatorial current contains between 20° and 30° W. longitude. From that place the salt of the Gulf Stream increases constantly during its course toward the northeast, viz, 36.105 per 1000, to 36,283 per 1,000. In 43° 26′ N. latitude, and 44° 19′ W. longitude, about 16 degrees of longitude to the east of the southern mouth of the St. Lawrence, between Nova Scotia and Newfoundland, it sinks suddenly to 33.854 per 1,000, and rises from thence slowly in its course toward the east to 34.102 and 35.597, until, midway between Newfoundland and the southwestern cape of Great Britain, it has risen to 35.896 per 1,000—a quantity of salt which diminishes very little in the whole North Atlantic Ocean between Scotland and Iceland. During this whole long course, from the Bay of Benin to Spitzbergen, this remarkable current shows a constant oscillation between the diluting influence of the large rivers and the evaporation occasioned by the high temperature of the current.

Now we shall try to trace its further progress. I have always thought that the East Greenland current was of Polar origin, and that it carried the waters from the large opening between Spitzbergen and the northernmost coast of Greenland into Davis' Straits, where it turns and mixes its waters with the Polar current that comes from the North American Polar Sea through Lancaster Sound and the numerous other sounds that connect Baffin's Bay with the American Polar Sea; but I never had an opportunity of making comparative analyses of the water from that but seldom visited part of the ocean. Colonel Schaffner had the kindness, on his voyage between the eastern part of Iceland and the south part of Greenland to take a number of samples, which I have analyzed, and the result of which will be found in my fourth region, the East Greenland current. The mean of twelve observations of water, taken for the greatest part by Colonel Schaffner, (three by Captain Gram,) is 35.278 per 1,000 salt, where one analysis of water, taken in the ice-pack, is left out, being no fair sample of sea-water from that region. In comparing this mean number with that of the North Atlantic Ocean, (35.391,) there will hardly be found any difference in the quantity of salt the two contain; while there is a great difference between these and the real Polar current of Baffin's Bay, which is 33.281 per 1,000, or of the Patagonian Polar current, (33.966.) I think we may infer from this fact that the East Greenland current is a returning branch of the Gulf Stream, and that the east coast of Greenland proportionally gives very few icebergs and very little glacial water to the sea. **Notes. 172-73.**

For comparison's sake I shall mention here that the sea, about midway between Norway and Spitzbergen, contains 35.222 per 1,000. I found the water taken on the south side of that island to contain 35.416 per 1,000, while that on the north side of Spitzbergen contained 33.623 per 1,000. The last-mentioned sample seems to be real Polar water, while all the water that flows between Norway, Spitzbergen, Iceland, and the east coast of Greenland partakes of the nature of the Gulf Stream.

Besides the reasons just mentioned for considering the East Greenland current to be a returning branch of the Gulf Stream—reasons which are deduced from the quantity of salt which the water contains—there are other reasons which lead to the same result. It is well known that the Gulf Stream brings tropical fruits from America to the coast of Norway, and it has once brought a river-vessel loaded with mahogany to the coast of the Faroe Islands. It is likewise known that similar fruits to those which are found on the Norwegian shores are carried by the sea to the coast of Iceland, and principally to the north and east coasts, where they only could get if the Gulf Stream turns between Spitzbergen and Iceland, and thus runs between Iceland and Greenland toward the southwest. It would be difficult to explain how a Polar current could bring tropical fruit to the north coast of Iceland.

On the west coast of Greenland the southeasterly wind brings in winter a mild temperature, and this fact is so generally known in the Danish colonies of Greenland that many of the colonists are convinced that there are volcanoes in the interior of that snow-clad land. The temperature which this current, that in winter and spring is full of drifting ice (not icebergs,) communicates, can, of course, not be above freezing-point, but that temperature is mild when the general temperature in winter is 8°, 10°, or 12° R. below the freezing-point. All these facts together leave hardly any doubt in my mind that it is the Gulf Stream which runs along the east coast of Greenland, and at last, in Davis' Straits, mixes its waters with the Polar current from Baffin's Bay. In its course toward the south it meets the main part of the Gulf Stream at Newfoundland, where it partly mixes with it to commence its circulation anew, partly dives under it, and runs as a ground-stream as far as the Equator. In a similar way the south branch of the Gulf Stream, which goes parallel to the western shores of South Europe and North Africa, joins the Equatorial current at its beginning in the Bay of Benin, and begins also its circulation anew.

[After discussing the "Chemical Decomposition in Sea Water," the author closes the paper with a tabular statement of all the analyses made by him and all others which have come to his knowledge. An abstract from these tables, embracing all the analyses of water obtained within or near the limits of the Gulf Stream, will be found on page 77, *et seq.*, of this volume.—HYDROGRAPHIC OFFICE.]

[173] Besides other places, pp. 221, 241, &c. [Pp. 313 and 322 of this volume.] **173.**

Notes.

174-80. [174] Besides other places, pp. 230 to 233. [Compare p. 319 of this volume.]

175. [175] Index map of Major Rennell's charts of currents in the Atlantic Ocean. (Rennell's Currents of the Atlantic Ocean. London, 1832.)

176. [176] Berghaus's Physikalischer Atlas, 2d part, Hydrography, No. 3.

177. [177] A. G. Findlay, Chart of the North Atlantic Ocean, with the Winds, Currents, and other Phenomena; 4 sheets. London, 1858.

178. [178] Becher, Bottle Chart of the Atlantic Ocean, 1843. (Nautical Magazine, 1843, p. 181.)

179. [179] Nautical Magazine, 1843, pp. 321, *et seq.*

180. [180] Compare the interesting treatise of James Croll, "On Ocean Currents," published in the London, Edinburgh, and Dublin Philosophical Magazine and Journal of Science, fourth series, February, 1870.

[The part referred to is the following:—HYDROGRAPHIC OFFICE.]

Part 1. Ocean Currents in relation to the Distribution of Heat over the Globe. The Absolute Heating Power of Ocean Currents.

There is perhaps no physical agent concerned in the distribution of heat over the surface of the globe whose influence has been so much underrated as that of ocean-currents. This is no doubt owing to the fact that, although a considerable amount of attention has been bestowed in ascertaining the surface-temperature, direction, and general influence of ocean-currents, still little or nothing has been done in the way of determining the absolute amount of heat or of cold conveyed by them, or the absolute increase or decrease of temperature, as the case may be, which must result from the heat or cold conveyed.

The modern method of determining the amount of heat-effects in absolute measure is, no doubt, destined to cast new light on all questions connected with climate, as it has done and is still doing in every department of physics where energy, under the form of heat, is the phenomenon under consideration. But this method has scarcely been attempted yet in questions of meteorology; and owing to the complicated nature of the phenomena with which the meteorologist has generally to deal, its application will very often be found practically impossible. Nevertheless it is particularly suitable to all questions regarding the direct thermal effects of currents, whatever the nature of those currents may happen to be.

In the application of the method to an ocean-current, the two most important elements which we require as data are the volume of the stream and its mean temperature. But although we know something of the temperature of most of the great currents of the ocean, yet, with the exception of the Gulf Stream, little is known regarding the volume of any of them.

Extensive and accurate observations have been made on the breadth, depth, and temperature of the Gulf Stream by the United States Coast Survey. In the memoirs and charts of the survey, cross sections of the stream at various places are given, showing its breadth and depth at those places, and also the temperature of the water from the surface downward to the bottom. We are thus enabled to determine pretty correctly the mean temperature of the stream. And knowing its mean velocity at any given section, we have likewise a means of determining the number of cubic feet of water passing through the section in a given time. But although we can obtain, with tolerable accuracy, the mean temperature, unfortunately observations regarding the velocity of the water at all depths have not been made at any particular section. Consequently we have no means of estimating, so accurately as we should have wished, the volume of the current. However, as we know the surface-velocity of the water at places where some of the sections were taken, we are thus enabled to make at least a rough estimate of the volume of the stream. **Note. 180. (Con'd.)**

From an examination of the published sections, some years ago, I came to the conclusion that the total quantity of water conveyed by the stream is probably equal to that of a stream 50 miles broad and 1,000 feet deep, flowing at the rate of four miles an hour, and that the mean temperature of the entire mass of moving water is not under 65° at the moment of leaving the Gulf. I think we are warranted to conclude that the stream, before it returns from its northern journey, is, on an average, cooled down to at least 40°; consequently it loses 25° of heat. Each cubic foot of water, therefore, in this case, carries from the tropics for distribution upward of 1,500 units of heat, or 1,158,000 foot-pounds. According to the above estimate of the size and velocity of the stream, 5,575,680,000,000 cubic feet of water are conveyed from the Gulf per hour, or 133,816,320,000,000 cubic feet daily. Consequently the total quantity of heat transferred from the Equatorial regions per day by the stream amounts to 154,959,300,000,000,000,000 foot-pounds. This estimate of the volume of the stream is considerably less than that given both by Captain Maury and by Sir John Herschel. Captain Maury considers the Gulf Stream equal to a stream 32 miles broad and 1,200 feet deep, flowing at the rate of five knots an hour. (Physical Geography of the Sea, § 24, 6th edition.) This gives 6,165,700,000,000 cubic feet per hour as the quantity of water conveyed by this stream. Sir John Herschel's estimate is still greater. He considers it equal to a stream 30 miles broad and 2,200 feet deep, flowing at the rate of four miles an hour. (Physical Geography, § 54.) This makes the quantity 7,359,900,000,000 cubic feet per hour.

From observations made by Sir John Herschel and by Mr. Pouillet on the direct heat of the sun, it is found that, were no heat absorbed by the atmosphere, about 83 foot-pounds per second would fall upon a square foot of surface placed at right angles to the sun's rays. Mr. Meech estimates that the quantity of heat cut off by the atmosphere is equal to about 22 per cent. of the total amount received from the sun. Mr. Pouillet estimates the loss at 24 per cent. Taking the former estimate, 64.74 foot-pounds per second will therefore be the quantity of heat falling on a square foot of the earth's surface when the sun is in the zenith. And were the sun to remain stationary in the zenith for twelve hours, 2,796,768 foot-pounds would fall upon the surface.

It can be shown that the total amount of heat received upon a unit surface on the Equator, during the twelve hours from sunrise to sunset, at the time of

Note.

180. (Con'd.) the equinoxes, is to the total amount which would be received upon that surface were the sun to remain in the zenith during those twelve hours, as the diameter of a circle to half its circumference, or as 1 to 1.5708. It follows, therefore, that a square foot of surface on the Equator receives from the sun, at the time of the equinoxes, 1,780.474 foot-pounds daily, and a square mile 49,636,750,000,000 foot-pounds daily. But this amounts to only $\frac{1}{3121870}$ part of the quantity of heat daily conveyed from the tropics by the Gulf Stream. In other words, the Gulf Stream conveys as much heat as is received from the sun by 3,121,870 square miles at the Equator. The amount thus conveyed is equal to all the heat which falls upon the globe within 63 miles on each side of the Equator. According to calculations made by Mr. Meech, the annual quantity of heat received by a unit surface on the frigid zone, taking the mean of the whole zone, is $\frac{5.45}{12}$ of that received at the Equator; consequently, the quantity of heat conveyed by the Gulf Stream in one year is equal to the heat which falls, on an average, on 6,873,800 square miles of the Arctic regions. The frigid zone, or Arctic regions, contain 8,130,000 square miles. There is actually, therefore, nearly as much heat transferred from the tropical regions by the Gulf Stream as is received from the sun by the entire Arctic regions, the quantity conveyed by the stream to that received from the sun by those regions being as 15 to 18.

But we have been assuming, in our calculations, that the percentage of heat absorbed by the atmosphere is no greater in the Polar regions than it is at the Equator, which is not the case. If we make due allowance for the extra amount absorbed in Polar regions, in consequence of the obliqueness of the sun's rays, the total quantity of heat conveyed by the Gulf Stream will probably nearly equal the amount received from the sun by the entire Arctic regions.

If we compare the quantity of heat conveyed by the Gulf Stream with that conveyed by means of aërial currents, the result is equally startling. The density of air to that of water is as 1 to 770, and its specific heat to that of water is as 1 to 4.2; consequently, the same amount of heat that would raise 1 cubic foot of water 1° would raise 770 cubic feet of air 4°.2, or 3,234 cubic feet 1°. The quantity of heat conveyed by the Gulf Stream is, therefore, equal to that which would be conveyed by a current of air 3,234 times the volume of the Gulf Stream, at the same temperature and moving with the same velocity. Taking, as before, the width of the stream at 50 miles, and its depth at 1,000 feet, and its velocity at 4 miles an hour, it follows that, in order to convey an equal amount of heat from the tropics by means of an aërial current, it would be necessary to have a current about $1\frac{1}{4}$ miles deep, and at the temperature of 65°, blowing at the rate of four miles an hour from every part of the Equator over the northern hemisphere toward the Pole. If its velocity were equal to that of a good sailing breeze, which Sir John Herschel states to be about twenty-one miles an hour, the current would require to be about 1,200 feet deep. A greater quantity of heat is probably conveyed by the Gulf Stream alone from the tropical to the temperate and arctic regions than by all the aërial currents that flow from the Equator.

We are apt, on the other hand, to overestimate the amount of the heat conveyed from tropical regions to us by means of aërial currents. The only currents which flow from the Equatorial regions are the upper currents, or anti-trades as they are called; but it is not possible that much heat can be conveyed directly by them. The upper currents of the trade-winds, even at the Equator, are nowhere below the snow-line; they must therefore lie in a

Note. 180. (Con'd.)

region actually below the freezing-point. In fact, if those currents were warm, they would elevate the snow-line above themselves. The heated air, rising off the hot, burning ground at the Equator, after ascending a few miles, becomes exposed to the intense cold of the upper regions of the atmosphere; it then very soon loses all its heat, and returns from the Equator much colder than it went thither. It is impossible that we can receive any heat directly from the Equatorial regions by means of aërial currents. It is perfectly true that the southwest wind, to which we owe so much of our warmth in this country, is a continuation of the anti-trade; but the heat which this wind brings to us is not derived from the Equatorial regions. This will appear evident if we but reflect that, before the upper current descends to the snow-line, after leaving the Equator, it must traverse a space of at least 2,000 miles; and to perform this long journey several days will be required. During all this time the air is in a region below the freezing-point; and it is perfectly obvious that, by the time it begins to descend, it must have acquired the temperature of the region in which it has been traveling.

If such be the case, it is evident that a wind whose temperature is below 32° could never warm a country such as ours, where the temperature does not fall below 38° or 39°. The heat of our southwest winds is derived, not directly from the Equator, but from the warm water of the Atlantic—in fact, from the Gulf Stream. The upper current acquires its heat after it descends to the earth. There is one way, however, whereby heat is indirectly conveyed from the Equator by the anti-trades; that is, in the form of aqueous vapor. In the formation of one pound of water from aqueous vapor, as Professor Tyndall strikingly remarks, a quantity of heat is given out sufficient to melt five pounds of cast-iron. It must, however, be borne in mind that the greater part of the moisture of the southwest and west winds is derived from the ocean in temperate regions. The upper current receives the greater part of its moisture after it descends to the earth, while the moisture received at the Equator is, in great part, condensed and falls as rain in those regions.

These as well as many other considerations which might be stated lead to the conclusion that, in order to raise the mean temperature of the whole earth, water should be placed along the Equator, and not land, as is generally believed. For, if land is placed at the Equator, the possibility of conveying the sun's heat from the Equatorial region by means of ocean-currents is prevented. The transference of heat could then be effected only by means of the upper currents of the trades; for the heat conveyed by *conduction* along the solid crust, if any, can have no sensible effect on climate. But these currents, as we have just seen, are ill adapted for conveying heat.

The surface of the ground at the Equator becomes intensely heated by the sun's rays. This causes it to radiate off its heat more rapidly into space than a surface of water heated under the same conditions. Again, the air in contact with the hot ground becomes also more rapidly heated than in contact with water, and consequently the ascending current of air carries off a greater amount of heat. But were the heat thus carried away transferred by means of the upper currents to high latitudes, and there employed to warm the earth, then it might, to a considerable extent, compensate for the absence of ocean-currents, and, in this case, land at the Equator might be nearly as well adapted as water for raising the temperature of the whole earth. But such is not the case; for the heat

Note.
180. carried up by the ascending current at the Equator is not employed in warming
(Con'd.) the earth, but is thrown off into the cold stellar space above. This ascending current, instead of being employed in warming the globe, is, in reality, one of the most effectual means that the earth has of getting quit of the heat received from the sun, and of thus maintaining a much lower temperature than it would otherwise possess. It is in the Equatorial regions that the earth loses as well as gains the greater part of its heat; so that, of all places, here ought to be placed the substance best adapted for preventing the dissipation of the earth's heat into space, in order to raise the general temperature of the earth. Water, of all substances in nature, seems to possess this quality to the greatest extent; and besides, it is a fluid, and therefore adapted, by means of currents, to carry the heat which is received from the sun to every region of the globe.

These results show (although they have reference to only one stream) that the general influence of ocean-currents on the distribution of heat over the surface of the globe must be very great. If the quantity of heat transferred from the Equatorial regions by the Gulf Stream alone is nearly equal to all the heat received from the sun by the Arctic regions, then how enormous must be the quantity conveyed from the Equatorial regions by all the ocean-currents put together!

Influence of the Gulf Stream on the Climate of Europe.—In a paper read before the British Association at Exeter, Mr. A. G. Findlay objects to the conclusions at which I have arrived in former papers on the subject, on these grounds, viz, first, that I have doubled the actual volume of the stream; second, that I have not taken into account the great length of time that the water requires in order to circulate, and the interference that it has to encounter in its passage.

Although I feel satisfied that the actual quantity of water conveyed from the Gulf of Mexico is as great, if not greater, than what I have estimated it to be, yet the influence of the stream on climate, as we shall presently see, is so enormous that, for our present purposes, it matters little whether we adopt Mr. Findlay's estimate or mine as the correct one.

In this case I shall adopt Mr. Findlay's estimate, and take the volume of the stream at one-half what I have concluded it to be. The quantity of heat conveyed would still be equal to all the heat received from the sun within 31½ miles on each side of the Equator, or equal to nearly one-half of the entire heat received by the Arctic regions.

I may here briefly consider the second objection, as it will afford an opportunity of referring to some important considerations bearing on the mode by which the heat of ocean-currents is distributed over the land.

The objection is, that a stream so comparatively small as the Gulf Stream, after spreading out over such a large area of the Atlantic, and moving so slowly across to the shores of Europe, losing heat all the way, would not be able to produce any very sensible influence on the climate of Europe.

I am unable to perceive the force of this objection. Why, the very efficiency of the stream as a heating agent necessarily depends upon the slowness of its motion. Did the Gulf Stream move as rapidly along its whole course as it does in the Straits of Florida, it could produce no sensible effect on the climate of Europe. It does not require much consideration to perceive this. (1.) If the stream during its course continued narrow, deep, and rapid, it would have little opportunity of losing its heat, and the water would carry back to the tropics the heat which it ought to have given off in the temperate and polar regions. (2.) The Gulf Stream does not heat the shores of Europe by direct radiation. Our island, for example, is not heated by radiation from a stream of warm water flowing along its shores. The Gulf Stream heats our island *indirectly* by heating the winds which blow over it to our shores. **Note. 180.** (Con'd.)

The anti-trades, or upper return-currents, as we have seen, bring no heat from the tropical regions. After traversing some 2,000 miles in a region of extreme cold, they descend on the Atlantic as a cold current, and there absorb the heat and moisture which they carry to northeastern Europe. Those aërial currents derive their heat from the Gulf Stream, or, if it is preferred, from the warm water poured into the Atlantic by the Gulf Stream.

How, then, are these winds heated by the warm water? The air is heated in two ways, viz, by direct *radiation* from the water, and by *contact* with the water. Now, if the Gulf Stream continued a narrow and deep current during its entire course similar to what it is at the Straits of Florida, it could have little or no opportunity of communicating its heat to the air either by radiation or by contact. If the stream was only about 40 or 50 miles in breadth, the aërial particles, in their passage across it, would not be in contact with the warm water more than an hour or two. Also the number of the particles in contact with the water, owing to the narrowness of the stream, would be small, and there would therefore be little opportunity for the air becoming heated by contact. The same also holds true in regard to radiation. The more we widen the stream and increase its area, the more we increase its radiating surface; and the greater the radiating surface, the greater is the quantity of heat thrown off. But this is not all; the number of aërial particles heated by radiation increases in proportion to the area of the radiating surface; consequently the wider the area over which the waters of the Gulf Stream are spread, the more effectual will the stream be as a heating-agent. And, again, in order that a very wide area of the Atlantic may be covered with the warm waters of the stream, slowness of motion is essential.

Mr. Findlay says that fully one-half of the Gulf Stream passes eastward and southward from the banks of Newfoundland, and supposes that it is only the northern portion of the current that can be effectual in raising the temperature of Europe. But it appears to me that it is to this southeastern portion of the current, and not to the northern, that we, in this country, are chiefly indebted for our heat. The southwest winds, to which we owe our heat, derive their temperature from this southeastern portion which flows away in the direction of the Azores. The southwest winds which blow over the northern portion of the current, which flows past our islands up into the Arctic seas, cannot possibly cross this country, but will go to heat Norway and Northern Europe. The northern portion of the stream, no doubt, protects us from the ice of Greenland by warming the northwest winds which come to us from that cold region.

Mr. Buchan, Secretary of the Scottish Meteorological Society, has shown that in a large tract of the Atlantic, between latitudes 20° and 40° N., the mean pressure of the atmosphere is greater than in any other place on the globe. To the west of Madeira, between longitude 10° and 40° W., the mean annual pressure amounts to 30.2 inches; while, between Iceland and Spitzbergen, it is only 29.6, a lower mean pressure than is found in any other place on the northern

Note.
180. hemisphere. There must consequently, he concludes, be a general tendency in
(Con'd.) the air to flow from the former to the latter place along the earth's surface. But the air, in moving from the lower to the higher latitudes, tends to take a northeasterly direction, and in this case will pass over our island in its course. But it so happens that this region of high pressure is situated in the very path of the southeastern branch of the Gulf Stream; consequently the winds blowing from this region of maximum pressure will carry directly to Britain the heat of the Gulf Stream.

It is essential to the heating of our island, as well as the southern portion of Europe, that a very large proportion of the waters of the Gulf Stream should spread over the surface of the Atlantic, and never pass up into the Arctic regions, as we shall presently see.

But even according to Mr. Findlay's own theory, it is to the southwest wind, heated by the warm waters of the Atlantic, that we are indebted for the high temperature of our climate. But he seems to be under the impression that the Atlantic would be able to supply the necessary heat independently of the Gulf Stream. This, I presume, is the fundamental error of all those who doubt the efficiency of the stream. It is a mistake, however, into which one is very apt to fall who does not adopt the more rigid method of determining heat-results in absolute measure. When we apply this method we find that the Atlantic, without the aid of such a current as the Gulf Stream, would be wholly unable to supply the necessary amount of heat to the southwest winds.

The quantity of heat conveyed by the Gulf Stream, as we have seen, is equal to all the heat received from the sun by 3,121,870 square miles at the Equator. Mr. Findlay, however, as has been stated, thinks that I have doubled the actual volume of the stream. Assuming that I have done so, the amount of heat carried by the stream would still be equal to all the heat received from the sun by 1,560,935 square miles at the Equator. The mean annual quantity of heat received from the sun by the temperate regions per unit-surface is to that received by the Equator as 9.08 to 12; consequently the quantity of heat conveyed by the stream, taking Mr. Findlay's estimate of its volume, is equal to all the heat received from the sun by 2,062,960 square miles of the temperate regions. The total area of the Atlantic, from the latitude of the Straits of Florida, 200 miles north of the tropic of Cancer, up to the Arctic circle, including also the German Ocean, is about 8,500,000 square miles. In this case the quantity of heat carried by the Gulf Stream into the Atlantic through the Straits of Florida, to that received by this entire area from the sun, is as 1 to 4.12, or, in round numbers, as 1 to 4. It therefore follows that one-fifth of all the heat possessed by the waters of the Atlantic over that area, even supposing that they absorb every ray that falls upon them, is derived from the Gulf Stream. Would those who call in question the efficiency of the Gulf Stream be willing to admit that a decrease of one-fourth in the total amount of heat received from the sun, over the entire area of the Atlantic from within 200 miles of the tropical zone up to the Arctic regions, would not sensibly affect the climate of Northern Europe? If they would not willingly admit this, why then contend that the Gulf Stream does not affect climate? for the stoppage of the Gulf Stream, taking it at Mr. Findlay's estimate, would deprive the Atlantic of 77,479,650,000,000,000,000 foot-pounds of energy in the form of heat per day—a quantity equal to one-fourth of all the heat received from the sun by that area.

How much, then, of the temperature of the southwest winds, derived from the water of the Atlantic, is due to the Gulf Stream? **Note, 180.** (Con'd.)

Were the sun extinguished, the temperature over the whole earth would sink to nearly that of stellar space, which, according to the investigations of Sir John Herschel and of Mr. Pouillet, is not above —239° F. Were the earth possessed of no atmosphere, the temperature of its surface would sink to exactly that of space, or to that indicated by a thermometer exposed to no other heat-influence than that of radiation from the stars. But the presence of the atmospheric envelope would slightly modify the conditions of things; for the heat from the stars (which of course constitutes what is called the temperature of space) would, like the sun's heat, pass more freely through the atmosphere than the heat radiated back from the earth, and there would, in consequence of this, be an accumulation of heat on the earth's surface. The temperature would therefore stand a little higher than that of space; or, in other words, it would stand a little higher than it would otherwise do were the earth exposed in space to the direct radiation of the stars without the atmospheric envelope. But, for reasons which will presently be stated, we may, in the mean time, till further light is cast upon this matter, take —239° F. as probably not far from what would be the temperature of the earth's surface were the sun extinguished.

Suppose, now, that we take the mean annual temperature of the Atlantic at say 56°.* Then 239°+56°=295° represents the number of degrees of rise due to the heat which it receives. In other words, it takes all the heat that the Atlantic receives to maintain its temperature 295° above the temperature of space. Stop the Gulf Stream, and the Atlantic would be deprived of one-fifth of the heat which it possesses. Then, if it takes five parts of heat to maintain a temperature of 295° above that of space, the four parts which would remain after the stream was stopped would only be able to maintain a temperature of four-fifths of 295°, or 236° above that of space; the stoppage of the Gulf Stream would therefore deprive the Atlantic of an amount of heat which would be sufficient to maintain its temperature 59° above what it would otherwise be, did it depend alone upon the heat received directly from the sun. It does not, of course, follow that the Gulf Stream actually maintains the temperature 59° above what it would otherwise be, were there no ocean-currents; because the actual heating-effect of the stream is neutralized to a very considerable extent by cold currents from the Arctic regions. But 59° of rise represents its actual power; consequently 59°, minus the lowering effect of the cold currents, represents the actual rise. What the rise may amount to at any particular place must be determined by other means.

This method of calculating how much the temperature of the earth's surface would rise or fall from an increase or a decrease in the absolute amount of heat received is that adopted by Sir John Herschel in his "Outlines of Astronomy," § 369[a]. About three years ago, in an article in the "Reader," I endeavored to show that this method is not rigidly correct. It has been shown from the experiments of Dulong and Petit, Dr. Balfour Stewart, Professor Draper, and others, that the rate at which a body radiates its heat off into space is not directly proportionate to its absolute temperature. The rate at which a body loses its heat,

* The mean temperature of the Atlantic between the Tropics and the Arctic Circle, according to Admiral Fitz Roy's chart, is about 60°. But he assigns far too high a temperature for latitudes above 50°; it is probable that 56° is not far from the truth.

Note.
180. (Con'd.) as its temperature rises, increases more rapidly than the temperature. As a body rises in temperature, the rate at which it radiates off its heat increases; but the *rate* of this increase is not uniform, but increases with the temperature. Consequently the temperature is not lowered in proportion to the decrease of the sun's heat. But at the comparatively low temperature with which we have at present to deal, the error resulting from assuming the decrease of temperature to be proportionate to the decrease of heat would not be great.

It may be observed, however, that the experiments referred to were made on solids; but, from certain results arrived at by Dr. Balfour Stewart, it would seem that the radiation of a material particle may be proportionate to its absolute temperature. This physicist found that the radiation of a thick plate of glass increases more rapidly than that of a thin plate as the temperature rises, and that, if we go on continually diminishing the thickness of the plate whose radiation at different temperatures we are ascertaining, we find that as it grows thinner and thinner the rate at which it radiates off its heat as its temperature rises becomes less and less. In other words, as the plate grows thinner and thinner, its rate of radiation becomes more and more proportionate to its absolute temperature. And we can hardly resist the conviction that if we could possibly go on diminishing the thickness of the plate till we reached a film so thin as to embrace but only one particle in its thickness, its rate of radiation would be proportionate to its temperature.

Dr. Balfour Stewart has very ingeniously suggested the probable reason why the rate of radiation of thick plates increases with rise of temperature more rapidly than that of thin. It is this: All substances are more diathermanous for heat of high temperatures than for heat of low temperatures. When a body is at a low temperature we may suppose that only the exterior rows of particles supply the radiation, the heat from the interior particles being all stopped by the exterior ones, the substance being very opaque for heat of low temperature; while at a high temperature we may imagine that part of the heat from the interior particles is allowed to pass, thereby swelling the total radiation. But as the plate becomes thinner and thinner the obstructions to interior radiation become less and less, and as these obstructions are greater for radiation at low temperatures than for radiation at high temperatures, it necessarily follows that by reducing the thickness of the plate we assist radiation at low temperatures more than we do at high.

In a gas, where each particle may be assumed to radiate by itself, and where the particles stand at a considerable distance from one another, the obstruction to interior radiation must be far less than in a solid. In this case the rate at which a gas radiates off its heat as its temperature rises must increase more slowly than that of a solid substance. In other words, its rate of radiation must correspond more nearly to its absolute temperature than that of a solid. If this be the case, a reduction in the amount of heat received from the sun, owing to an increase of his distance, should tend to produce a greater lowering effect on the temperature of the air than it does on the temperature of the solid ground. But as the temperature of our climate is determined by the temperature of the air, it must follow that the error of assuming that the decrease of temperature would be proportionate to the decrease in the intensity of the sun's heat may not be great.

It may be noticed here, although it does not bear directly on this point, that although the air in a room, for example, or at the earth's surface, is principally cooled by convection rather than by radiation, it is by radiation alone that the earth's atmosphere parts with its heat to stellar space; and this is the chief matter with which we are at present concerned. Air, like all other gases, is a bad radiator; and this tends to protect it from being cooled to such an extent as it would otherwise be, were it a good radiator like solids. True, it is also a bad absorber; but as it is cooled by radiation into space, and heated, not altogether by absorption, but to a very large extent by convection, it on the whole gains its heat more easily than it loses it, and consequently must stand at a higher temperature than it would do were it heated alone by absorption. **Note. 180.** (Con'd.)

But, to return: the error of regarding the decrease of temperature as proportionate to the decrease in the amount of heat received, is probably neutralized by one of an opposite nature, viz, that of taking space at too high a temperature; for by so doing we make the result too small.

We know that absolute zero is at least 493° below the melting-point of ice. This is 222° below that of space. Consequently, if the heat derived from the stars is able to maintain a temperature of —239°, or 222° of absolute temperature, then nearly as much heat is derived from the stars as from the sun. But, if so, why do the stars give so much heat and so very little light? If the radiation from the stars could maintain a thermometer 222° above absolute zero, then space must be far more transparent to heat-rays than to light-rays, or else the stars give out a great amount of heat, but very little light, neither of which suppositions is probably true. The probability is, I venture to presume, that the temperature of space is not very much above absolute zero. At the time when these investigations into the probable temperature of space were made, at least as regards that by Pouillet, the modern science of heat had no existence, and little or nothing was then known with certainty regarding absolute zero. In this case the whole matter would require to be reconsidered. The result of such an investigation, in all probability, would be to assign a lower temperature to stellar space than —239°.

Taking all these various considerations into account, it is probable that if we adopt —239° as the temperature of space, we shall not be far from the truth in assuming that the absolute temperature of a place above that of space is proportionate to the amount of heat received from the sun. We may, therefore, in this case conclude that 59° of rise is probably not very far from the truth as representing the influence of the Gulf Stream. The Gulf Stream, instead of producing little or no effect, produces an effect far greater than is generally supposed.

Our island has a mean annual temperature of about 12° above the normal due to its latitude. This excess of temperature has been justly attributed to the influence of the Gulf Stream. But it is singular how this excess should have been taken as the measure of the *rise resulting from the influence of the stream.* These figures only represent the number of degrees that the mean normal temperature of our island stands above what is called the normal temperature of the latitude.

The way Professor Dove constructed his tables of normal temperature was as follows: He took the temperature of thirty-six equidistant points on every ten degrees of latitude. The mean temperature of these thirty-six points he calls, in each case, the *normal* temperature of the parallel. The excess above the normal merely represents how much the stream raises our temperature above

Note.
180. (Con'd.) the mean of all places on the same latitude, but it affords us no information regarding the absolute rise produced. In the Pacific, as well as in the Atlantic, there are immense masses of water flowing from the tropical to the temperate regions. Now, unless we know how much of the normal temperature of a latitude is due to ocean-currents, and how much to the direct heat of the sun, we could not possibly, from Professor Dove's tables, form the most distant conjecture as to how much of our temperature is derived from the Gulf Stream. The overlooking of this fact has led to a general misconception regarding the positive influence of the Gulf Stream on temperature. The 12° marked in tables of normal temperature do not represent the absolute effect of the stream, but merely how much the stream raises the temperature of our country above the mean of all places on the same latitude. Other places have their temperature raised by ocean-currents as well as this country; only the Gulf Stream produces a rise of several degrees over and above that produced by other streams in the same latitude.

At present there is a difference merely of 80° between the mean temperature of the Equator and the Poles; but were each part of the globe's surface to depend alone upon the direct heat which it receives from the sun, there ought, according to theory, to be a difference of more than 200°. The annual quantity of heat received at the Equator to that received at the Poles, supposing the proportionate quantity absorbed by the atmosphere to be the same in both cases, is as 12 to 4.98, or say as 12 to 5. Consequently, if the temperatures of the Equator and the Poles be taken as proportionate to the absolute amount of heat received from the sun, then the temperature of the Equator above that of space must be to that of the Poles above that of space as 12 to 5. What ought, therefore, to be the temperatures of the Equator and the Poles, did each place depend solely upon the heat which it received directly from the sun? Were all ocean and aërial currents stopped, so that there could be no transference of heat from one part of the earth's surface to the other, what ought to be the temperatures of the Equator and the Poles? We can, at least, arrive at a rough estimate on this point. If we diminish the quantity of warm water conveyed from the equatorial regions to the temperate and arctic regions, the temperature of the Equator will begin to rise and the temperature of the Poles to sink. It is probable, however, that this process would affect the temperature of the Poles more than it would do that of the Equator; for as the warm water flows from the Equator to the Poles, the area over which it is spread becomes less and less. But as the water from the Tropics has to raise the temperature of the temperate regions as well as the polar, the difference of effect at the Equator and Poles might not, on that account, be so very great. Let us take a rough estimate. Say that, as the temperature of the Equator rises one degree, the temperature of the Poles sinks one degree and a half. The mean annual temperature of the globe is about 58°. The mean temperature of the Equator is 80°, and that of the Poles 0°. Let ocean and aërial currents now begin to cease, the temperature of the Equator begins to rise and the temperature of the Poles to sink. For every degree that the Equator rises the Poles sink $1\frac{1}{2}$°; and when the currents are all stopped and each place dependent alone upon the direct rays of the sun, the mean annual temperature of the Equator, above that of space, will be to that of the Poles, above that of space, as 12 to 5. When this proportion is reached, the Equator will be 374° above that of space, and the Poles 156°; for 374 is to 156 as 12 is to 5. The temperature of space we have seen to be —239°; consequently the temperature of the Equator will, in this case, be 135°, reckoned from the zero of the Fahrenheit thermometer, and the Poles 83° below zero. The Equator would therefore be 55° warmer than at present, and the poles 83° colder. The difference between the temperature of the Equator and the Poles will, in this case, amount to 218°. Note. 180. (Con'd.)

Now, if we take into account the quantity of positive energy in the form of heat carried by warm currents from the Equator to the temperate and polar regions, and also the quantity of negative energy (cold) carried by cold currents from the polar regions to the Equator, we shall find that they are sufficient to reduce the difference of temperature between the Poles and the Equator from 218° to 80°.

The quantity of heat received in the latitude of London, for example, to that received at the Equator is about as 12 to 8. This, according to theory, should produce a difference of about 125°. The temperature of the Equator above that of space, as we have seen, would be 374°. Therefore 249° above that of space would represent the temperature of the latitude of London. This would give 10° as its temperature. The stoppage of all ocean and aërial currents would thus increase the difference between the Equator and the latitude of London by about 85°. The stoppage of ocean-currents would not be nearly so much felt, of course, in the latitude of London as at the Equator and the Poles, because, as has been already noticed, in all latitudes midway between the Equator and the Poles the two sets of currents, to a considerable extent, compensate each other; viz, the warm currents from the Equator raise the temperate, while the cold ones from the Poles lower it; but as the warm currents chiefly keep on the surface and the cold return-currents are principally under-currents, the heating effect very greatly exceeds the cooling effect.

Now, as we have seen, the stoppage of all currents would raise the temperature of the Equator 55°; that is to say, the rise at the Equator alone would increase the difference of temperature between the Equator and that of London by 55°. But the actual difference, as we have seen, ought to be 85°; consequently the temperature of London would be lowered 30° by the stoppage of the currents. For if we raise the temperature of the Equator 55°, and lower the temperature of London 30°, we then increase the difference by 85°. The normal temperature of the latitude of London being 40°, the stoppage of all ocean and aërial currents would thus reduce it to 10°. But the Gulf Stream raises the actual mean temperature of London 10° above the normal; consequently 30°+10°=40° represents the actual rise at London due to the influence of the Gulf Stream, over and above all the lowering effects resulting from Arctic currents: On some parts of the American shores, on the latitude of London, the temperature is 10° below the normal. The stoppage of all ocean and aërial currents would therefore lower the temperature there only 20°.

It is at the Equator and the Poles that the great system of ocean and aërial currents produces its maximum effects. The influence becomes less and less as we recede from those places, and between them there is a point where the influence of the warm currents from the Equator and cold currents from the Poles exactly neutralize each other. At this point the stoppage of ocean-currents would not sensibly affect temperature. This point, of course, is not situated on the same latitude in all meridians, but varies according to the position of the

Note.
180. (Con'd.) meridian in relation to land and ocean currents, whether cold or hot, and other circumstances. A line drawn round the globe through these various points would be very irregular. At one place, such as on the western side of the Atlantic, where the Arctic current predominates, the neutral line would be deflected toward the Equator, while on the eastern side, where warm currents predominate, the line would be deflected toward the north. It is a difficult problem to determine the mean position of this line; it probably lies somewhere not far north of the Tropics.

Influence of the Gulf Stream on the climate of the Arctic Regions.—Does the Gulf Stream pass into the Arctic regions? Are the seas around Spitzbergen and North Greenland heated by the warm water of the stream?

Those who deny this, nevertheless admit the existence of an Arctic current. They admit that an immense mass of cold water is continually flowing south from the Polar regions around Greenland into the Atlantic. Then, if it is admitted that there is a mass of water flowing across the Arctic circle from north to south, it must also be admitted that there is an equal mass flowing across from south to north. It is also evident that the water crossing from south to north must be warmer than the water crossing from north to south; for the temperate regions are warmer than the Arctic, and the ocean in temperate regions warmer than the ocean in the Arctic; consequently the current which flows into the Arctic seas, to compensate for the cold Arctic current, must be a warmer current.

Is the Gulf Stream this warm current? Does this compensating warm current proceed from the Atlantic, or from the Pacific? If it proceeds from the Atlantic it is simply the warm water of the Gulf Stream. We may call it the warm water of the Atlantic if we choose; but this cannot materially affect the question at issue, for the heat which the waters of the Atlantic possess is derived, as we have seen, to an enormous extent, from the water brought from the Tropics by the Gulf Stream. Then, if we deny that the warm compensating current comes from the Atlantic, we must assume that it comes from the Pacific. But if the cold current flows from the Arctic regions into the Atlantic, and the warm compensating current from the Pacific into the Arctic regions, the highest temperature should be found on the Pacific side of the Arctic regions, and not on the Atlantic side; but the reverse is the case. In the Atlantic, for example, the 41° isothermal line of mean annual temperature reaches to latitude 65° 30′, while in the Pacific it nowhere goes beyond latitude 57°. The 27° isothermal of mean annual temperature reaches to latitude 75° in the Atlantic, but in the Pacific it does not pass beyond 64°. And the 14° isothermal reaches the north of Spitzbergen in latitude 80°, whereas on the Pacific side of the Arctic regions it does not reach to latitude 72°.

On no point of the earth's surface does the mean annual temperature rise so high above the normal as in the Northern Atlantic, just at the Arctic circle, at a spot believed to be in the middle of the Gulf Stream. This place is no less than 22°.5 above the normal, while in the Northern Pacific the temperature does not anywhere rise more than 9° above the normal. These facts prove that the warm current passes up the Atlantic into the Arctic regions, and not up the Pacific, or at least that the larger amount of warm water must pass into the Arctic regions through the Atlantic. In other words the Gulf Stream is the warm compensating current. Not only must there be a warm stream, but one of very considerable magnitude, in order to compensate for the great amount of cold water that is constantly flowing from the Arctic regions, and also to maintain the temperature of those regions so much above the temperature of space as they actually are. Notes. 180-84.

No doubt, when the results of the late dredging-expedition in the North Sea are published, they will cast much additional light on the direction and character of the currents forming the northeastern branch of the Gulf Stream.

The average quantity of heat received by the Arctic regions as a whole per unit surface to that received at the equator, as we have already seen, is as 5.45 to 12, assuming that the percentage of rays cut off by the atmosphere is the same at both places. In this case the mean annual temperature of the Arctic regions, taken as a whole, would be about —69°, did those regions depend alone for their temperature upon the heat received directly from the sun. But the temperature would not even reach to this; for the percentage of rays cut off by the atmosphere in Arctic regions is generally believed to be greater than at the Equator, and consequently the actual mean quantity of heat received by the Arctic regions will be less than $\frac{5.45}{12}$ of what is received at the Equator.

In the article on "Climate," in the *Encyclopedia Britannica*, there is a table calculated upon the principle that the quantity of heat cut off is proportionate to the number of aërial particles that the rays have to encounter before reaching the surface of the earth—that, as a general rule, if the tracts of the rays follow an arithmetical progression, the diminished force with which the rays reach the ground will form a decreasing geometrical progression. According to this table about 75 per cent. of the sun's rays are cut off by the atmosphere in Arctic regions. But if 75 per cent. of the rays were cut off by the atmosphere in Arctic regions, then the direct rays of the sun could not maintain a mean temperature 100° above that of space. But this is no doubt by far too high a percentage for the quantity of heat cut off, for recent discoveries in regard to the absorption of radiant heat by gases and vapors prove that tables computed on this principle must be incorrect. The researches of Tyndall and Melloni show that when rays pass through any substance, the absorption is rapid at first; but the rays are soon "sifted," as it is called, and they then pass onward with but little further obstruction. Still, however, owing to the dense fogs which prevail in Arctic regions, the quantity of heat cut off must be considerable.

If as much as 50 per cent. of the sun's rays are cut off by the atmosphere in Arctic regions, the amount of heat received directly from the sun is not sufficient to maintain a mean annual temperature of —100°. Consequently the Arctic regions must depend, to an enormous extent, upon ocean-currents for their temperature.

*   *   *   *   *   *   *

[181] I am preparing a memoir "on the explorations north of Spitzbergen." and will not enter here on details. 181.

[182] Compare Gumprecht in the "Zeitschrift für Erdkunde," 1854, vol. 3, p. 432. 182.

[183] "Zeitschrift für Erdkunde," new series, vol. 6, table 2. 183.

[184] Geographische Mittheilungen, 1865, p. 158. 184.

B.

REFERENCES AND NOTES TO THE FIRST SUPPLEMENT TO DR. PETERMANN'S PAPER: THE TEMPERATURE OF THE NORTH ATLANTIC OCEAN AND THE GULF STREAM.

BY ADMIRAL IRMINGER

Notes.
185-94. [185] Havet's Strömninger af Capt. Irminger. Nyt Archiv for Sövosenet, 1853.

186. [186] Already on the chart appended to my memoir "Havet's Strömninger" I have indicated some bands; on the same chart it may also be seen how the temperature is getting lower the nearer Greenland is approached.

187. [187] Investigation of the currents of the Atlantic Ocean, by James Rennell, F. R. S., London, 1832, p. 165.

188. [188] Findlay mentions that the temperature at the depth of 1,200 feet was found to be only 55°, while on the surface of the Gulf Stream it reached 77°.4. (Proceedings R. G. S., vol. xiii, No. 3.) In the Florida Straits, where the velocity of the Gulf Stream is greatest, the temperature at 4,800 feet was found to be only 38°.1. (Coast Survey Report, 1859.)

189. [189] Havet's Strömninger. Nyt Archiv for Sövosenet, 1853, p. 127.

190. [190] Proceedings of the Royal Geographical Society, London, 1869, No. 3, p. 231.

191. [191] A voyage of discovery toward the North Pole, by Captain Beechey, R. N., F. R. S., London, 1843, p. 343.

192. [192] An account of the Arctic regions and northern whale-fishery, by W. Scoresby junior, F. R. S. E., Edinburgh, 1820, p. 210.

193. [193] Havet's Strömninger. Nyt Archiv for Sövosenet, 1853, p. 124.

194. [194] Strömninger og Iisdrift ved Island, af Commandeur Capitain C. Irminger. Nyt Archiv for Sövosenet, 1861.

C.

REFERENCES AND NOTES TO THE SECOND SUPPLEMENTS TO DR. PETERMANN'S PAPER: THE METEOROLOGICAL OBSERVATIONS OF TOBIESEN.

Notes.

[195] Kongl. Vetenskaps Akademiens Handlingar, (Transactions of the Royal Academy of Sciences,) 1869, No. 11. The translation of the introduction from the Swedish is by Dr. C. F. Frisch. The table has been newly arranged by me, and the observations (originally in Celsius's scale) turned into Fahrenheit's scale. 195-98.

[196] The correction is by Professor Mohn, Director of the Meteorological Institute at Christiania. 196.

[197] The observations for the position were obtained in unfavorable weather, and are therefore not entirely reliable. 197.

[198] Compare the sketch table 8, Geographische Mittheilungen, 1870, part iv. 198.

D.

REFERENCES AND NOTES TO DR. VON FREEDEN'S DISCOURSE.

Notes.

199-201. [199] Besides the well-known expedition of General Sabine and Colonel Clavering for pendulum and magnetic observations in 1823, (see note 99,) by which the sea along the east coast of Greenland was found to be navigable to and beyond the parallel of latitude 75° 14′ N., there are on record for that region the discovery, in 1635, of Edam Land in latitude 77° 40′ N., and longitude 20° 40′ W., and of high land seen 1670 in latitude 79° 10′ N., and longitude 21° 50′ W. Scoresby, however, discovered in 1823 errors of longitude in the charts of Greenland amounting to 14°; and the late Swedish expedition, when making deep-sea soundings off Prince Charles Foreland in longitude 4° to 6° E. of Greenwich, believed themselves to be but 160 nautical miles from the Greenland coast; as in latitude 79°, one degree of longitude is equal to about 12 nautical miles, the coast might be looked for there as far east as longitude 10° W. of Greenwich.

The question also remains yet to be solved whether Greenland is an island, the north coast of which turns in about latitude 80° N. to the westward, perhaps to the Kennedy Channel, where Morton, one of Dr. Kane's men, reported to have heard and seen the free Northern Sea "rolling along with the motions of the infinite ocean;" or whether General Sabine is correct in assuming (because he did find no current at all in the summer along the Greenland coast) that in about latitude 76° N. it makes out far to the eastward; or, lastly, whether Dr. Petermann's hypothesis turns out to be true, according to which Greenland extends past the Pole to Wrangell's Land, lately discovered by Captain Long in the vicinity of Behring's Straits.

200. [200] Gillis Land is frequently called "the mythical." The first accounts of land seen east of Spitzbergen date from 1707; subsequently it has been seen by the Swedish expeditions, which even attempted to trace and locate the coasts; but no one has thus far set foot upon it. (Compare note 126.)

201. [201] The reports on the currents in the Northern Sea differ much in the various parts, and for the various seasons. The expedition, as will be seen from its journal, (see abstract in note 206,) has found prevailing in the eastern part of the sea a warm current to the north and northeast, and in the western part a cold compensation current to the southwest. General Sabine, on the contrary, states as follows: "Notwithstanding the many reports, by whalers, of a strong southerly current running constantly along the east coast of Greenland, we never found there a current, most surely not near the coast, with the exception of a single day, when the difference of latitudes by observations was eighteen miles greater than by dead reckoning; the tides, also, we found scarcely perceptible, the rise and fall amounting only to three feet." And at another place: "The winds only appeared to cause now and then a weak current." Lastly, in a private letter to Dr. Petermann: "No current was found on the entire route from Spitzbergen to Greenland, on which observations were made very frequently by three or four experienced officers, and the courses of the vessel recorded hourly." **Note. 201.** (Con'd.)

Parry's experience in the southwest stream is too well known to be mentioned again here. He turned back July 7, 1827, because the stream did set the ship each day as much, and even more, to the southward, than she would go through the water on her northern course. When in latitude 58° N., longitude 8° W. of Greenwich, he observed the Gulf Stream to extend in a northeastern direction with a velocity of from five to thirteen miles per day.

Scoresby when on the 22d of May 1822 off the Greenland Coast in latitude 76° N., had drifted in twelve days 100 miles to the southward, but in latitude 72° N., and longitude 19½° W., nearer to the coast, he found a weak northwestern current, and on the 26th of August, in 71° 50′ N., and 21° 00′ W., close to the land, a strong westerly stream, where in July an easterly current from the land had been observed. These latter depend upon the melting of the snow in the interior of Greenland.

In general the currents will be found to flow as recorded in the following table :

Currents observed by Captain Koldeway during the first German North Polar Expedition, 1868.

Date.	Position at noon. Lat.	Position at noon. Long. from Greenwich.	Direction and velocity of the current in the preceding 24 hours.
	° ′	° ′	
May 25	61 57 N.	1 29 E.	
26	63 56 N.	0 04 E.	E., 30 naut. miles.
27	65 17 N.	1 07 W.	N.NE. ¾ E., 12 m.
28	66 41 N.	0 50 W.	SE. ½ S., 23 miles.
29	68 09 N.	0 34 W.	No current.
No record in this interval.			
June 7	75 01 N.	11 03 W.	
8	75 19 N.	12 48 W.	S.SW., 11 miles.
From June 8th to 23d beset by ice			
June 23	73 31 N.	15 27 W	S.SW., 11 miles, (average drift.)
24	74 13 N.	14 13 W.	SW. by S., 12 miles.
25	74 12 N.	14 00 W.	Do.
26	74 36 N.	13 55 W.	S. by W. ¼ W., 9.m.
27	75 15 N.	12 52 W.	Do.
28	75 52 N.	12 11 W.	Do.
29	75 10 N.	11 47 W.	Do.
30	75 08 N.	6 11 W.	W.SW., 11 miles.
July 1	75 02 N.	2 52 E.	SW. ¼ S., 21 miles.
2	75 34 N.	9 17 E.	S. by W. ¾ W., 16 m.
3	76 34 N.	15 52 E.	E. ½ N., 8 miles.
4	76 03 N.	18 07 E.	S.SE., 12 miles.
5	75 40 N.	22 59 E.	SW. ½ W., 13 miles.
6	75 38 N.	23 37 E.	Do.
7	75 39 N.	19 25 E.	W. ½ S., 10 miles.
No records in the interval.			
July 15	77 38 N.	14 34 E.	
16	78 00 N.	11 39 E.	N. ½ E., 4 miles.
19	80 13 N.	5 52 E.	
20	79 15 N.	4 00 E.	SW. ¾ W., 22 miles.
21	77 40 N.	4 33 E.	N.NE. ¼ E., 18 m.
22	76 17 N.	0 18 W.	
23	75 50 N.	2 51 W.	W.SW., 5 miles.
No record in the interval.			
Aug. 2	73 35 N.	14 03 W.	
3	73 19 N.	16 37 W.	SW., 9 miles.
4	73 23 N.	17 21 W.	Do.
5	73 25 N.	17 22 W.	Do.
6	73 23 N.	16 34 W.	Do.
7	73 20 N.	16 01 W.	SW. by W., 13 miles.
8	73 08 N.	11 46 W.	S., 13 miles.
9	72 56 N.	9 06 W.	S.SW. ¾ W., 15 m.
10	72 22 N.	6 36 W.	Do.
11	72 45 N.	2 27 W.	Do.
12	72 33 N.	2 07 W.	Do.
13	73 15 N.	3 10 W.	S.SW. ¾ W., 7 miles.
14	73 51 N.	1 43 W.	SE. by S., 11 miles.
15	75 44 N.	0 09 W.	S.SE., 10 miles.
16	77 54 N.	4 16 E.	Do.
17	79 06 N.	10 06 E.	Do.
18	80 00 N.	14 17 E.	SE. by E. ¾ E., 7 m.
No record in the interval.			
Sept. 14	80 42 N.	15 57 E.	
15	80 16 N.	13 37 E.	E., 10 miles.
16	80 14 N.	6 37 E.	N.NE. ¾ E., 13 m.
17	78 58 N.	8 10 E.	N.NE. ¾ E., 14 m.
18	77 05 N.	7 36 E.	N., 12 miles.
19	76 11 N.	5 19 E.	Do.
20	74 55 N.	4 42 E.	Do.
21	73 15 N.	3 17 E.	N. by E. ¼ E., 8 m.
22	72 34 N.	3 24 E.	Do.
23	71 40 N.	3 16 E.	Do.
No records in the interval.			
Sept. 28	60 46 N.	4 16 E.	Strong northerly.
29	60 39 N.	4 53 E.	Do.

Notes.

201-6. The currents recorded above apply to the interval from noon to noon; for instance, the first record, "E. 30 miles," is for the distance between the position of the ship at noon of May the 25th, and that at noon of May the 26th. This first observation is remarkable in direction as well as in force. The vicinity of the coast which is studded there with islets and abounds in deep inlets, may cause the general current to be deflected locally in the stated direction.

202. [202] The commander of the North German whaler Hannover expressly stated "that there had never been so much ice everywhere as during this year."

Previous to speaking that ship, when the Greenland was yet drifting in the ice, she came, hid by the fog, in the vicinity of an English vessel, also drifting with the ice, the mate of which, supposing her abandoned, came with some sailors to take possession, and was much astonished when he saw the heads of the crew, one by one, appearing over the hammock nettings.

203. [203] Among other things a pumpkin was seen, but could not be fished. The drift-wood consists principally of pine wood, (branches, trunks, and roots,) smooth and knotty pieces, piled up in great quantities, especially on the east coast of Spitzbergen and the small islands north of it, and coming mostly from the Siberian main. Scoresby found it as low as latitude 66° N. in longitude 4° W. of Greenwich.

204. [204] Scoresby also mentions fields of ice of forty miles in length, and 700 to 800 square miles in area, (more than half as large as the State of Rhode Island.—HYDROGRAPHIC OFFICE.)

205. [205] Mr. Petermann supposes that whaling vessels have been higher north than latitude 81° N.

206. [206] A complete copy of the journal of the expedition, embracing all the observations which usually were taken at regular intervals six times a day, would require too much space.

The following is an abstract, containing the position of the ship at noon of each day; the direction and force of the wind at noon; the reduced observation of the barometer in English inches, at noon and the daily mean; the temperature of the air at noon the daily mean, the normal mean temperature of the place according to Dove and the difference of the two latter, all in Fahrenheit's scale; the temperature of the surface of the sea at noon, and the daily mean; the number of hours of fog, (F.,) rain, (R.,) snow, (S.,) and hail, (H.,) of each day; and the average state of the sky, (the form of the clouds and the proportion of the sky obscured.)

Should a meteorological Institute wish to obtain more detailed data, the North German Seewarte will very cheerfully furnish them as far as able. The daily mean barometer readings, and the daily mean temperature of the air and of the surface of the sea, are computed by the formula $\frac{1}{6}$ (16 hours + 20 hours + 0 hours + 4 hours + 8 hours + 12 hours.)

Note 206. (Con'd.)

Abstract of the journal of the First German North Polar Expedition, 1868.

Date.	Position at noon.		Wind at noon.		Barometer.		Temperature of air.				Temp. of sea.		Hours of fog, rain, hail, and snow.	State of sky.		Notes.
	Latitude.	Longitude from Greenwich.	Direction.	Force 0 to 12.	At noon.	Daily mean.	At noon.	Daily mean.	Normal.	Difference.	At noon.	Daily mean.		Form.	Prop. obscured 1 to 10.	
	° ′	° ′			″	″	°	°	°	°	°	°				
May 25	61 57 N.	1 29 E.	S.SE.	5	29.47	29.50	49	47.5	47.1	0.4	48	47.3	R. 5	Cu., Str.	6.5	Left Bergen, sailing northward.
26	63 56 N.	0 4 E.	S.SE.	4	29.57	29.52	51	48.6	46.6	2.0	47	46.8	R. 2	Cu., Ni	5.8	Sounded; no bottom.
27	65 17 N.	1 7 W.	S. by E.	4	29.45	29.43	50	47.3	44.1	3.2	44	44.0	R. 5	Cu., Ni	8.7	The Gulf Stream sets strongly northeast.
28	66 41 N.	0 50 W.	NW. by N.	6	29.78	29.79	47	43.0	43.9	— 0.9	44	42.1	F. 8, R. 2	Cu., Ni	9.3	At the limits of the Gulf Stream, judging by the temperature of the sea.
29	68 9 N.	0 34 W.	SE.	2	29.87	29.84	41	39.9	41.5	— 1.6	43	41.2	R. 4	Cu., Ni., Ci.	9.0	First attempt for Greenland.
30	70 22 N.	5 15 W.	E.NE.	8	29.47	29.51	37	35.8	38.1	— 2.3	34	35.0	R. 20, R. & S. 4	Ni	10	Sudden fall in the temperature of the sea.
31	70 15 N.	4 45 W.	N. by E.	7	29.67	29.71	33	32.5	38.3	— 5.8	36	35.0	S. 2	Cu., Ci., St.	10	Much drift-wood, very knotty.
June 1	70 30 N.	2 15 W.	NE.	1	29.93	29.87	35	34.9	38.1	— 3.2	39	37.2	R. 7, S. 1	Cu., Ci., St.	9.3	Several observations of deep-sea temp'rature.
2	72 48 N.	3 28 W.	SW.	4	29.52	29.52	34	32.7	36.5	— 3.8	31	30.8	F. 20, R. 4	Cov	10	Drift-wood; sea light blue; very transparent.
3	74 3 N.	5 2 W.	E.	3	29.46	29.45	32	32.5	34.5	— 2.0	31	30.6	F. 22, R. 1	Cov	10	Sea deep-blue; tackling covered by a thick ice-crust.
4	74 52 N.	6 7 W.	E.	0	29.42	29.48	36	31.8	33.1	— 1.3	32	30.4	F. 17	Cov	10	at 10 hours first drift ice, 12 feet in diameter.
5	74 54 N.	9 11 W.	E.	2	29.70	29.72	29	28.4	33.4	— 5.0	30	29.1		Cum	8.5	Between ice; passages open toward the west for miles.
6	75 6 N.	12 53 W.	S.	2	29.84	29.82	28	29.3	33.4	— 4.1	29	29.1		Cum	10	Drifting in the ice.
7	75 1 N.	11 3 W.	S.SW.	3	29.63	29.60	26	28.4	33.4	— 5.0	29	29.3	S. 6	Cov	10	Penetrating toward the west.
8	75 19 N.	12 48 W.	SE. by S.	6	29.21	29.23	30	31.1	33.4	— 2.3	30	29.5	R. 2, S. 16	Cov	10	Working back easterly in order not to be closed in.
9	75 10 N.	12 26 W.	E. by S.	9	29.27	29.27	31	32.0	33.8	— 1.8	30	29.7	S. 24	Cov	10	Beset by ice.
10	75 0 N.	13 45 W.	SE. by E.	3	29.39	29.41	32	32.9	34.9	— 2.0	30	29.7	F. 16, S. 8	Cov	10	Beset by ice.
11	74 53 N.	13 31 W.	N.NE.	4	29.56	29.56	33	32.7	35.4	— 2.7	30	29.7	F. 24	Cov	10	Beset by ice; five polar bears; shark of 12 feet.
12	74 43 N.	13 52 W.	NW. by N.	2	29.54	29.50	34	33.1	36.0	— 2.9	30	29.5	F. 6, S. 3	Cov	10	Beset by ice.
13	74 31 N.	14 13 W.	N.	8	29.37	29.36	34	33.1	36.7	— 3.6	30	29.7	S. 15	Cov	10	Do.
14	74 18 N.	14 34 W.	N.	4	29.51	29.50	32	32.0	37.4	— 5.4	30	29.7	S. 11	Cov	10	Beset by ice; one polar bear.

Note. 206. (Con'd.)

Abstract of the journal of the First German North Polar Expedition, 1868—Continued.

Date.	Position at noon.		Wind at noon.		Barometer.		Temperature of air.				Temp. of sea.		Hours of fog, rain, hail, and snow.	State of sky.		Notes.
	Latitude.	Longitude from Greenwich.	Direction.	Force 0 to 12.	At noon.	Daily mean.	At noon.	Daily mean.	Normal.	Difference.	At noon.	Daily mean.		Form.	Prop. obscured 1 to 10.	
	° ′	° ′			″	″	°	°	°	°	°	°				
June 15	74 7 N.	15 4 W.	N. ½ E.	6	29.62	29.63	32	30.2	40.3	— 10.1	29	29.1	S. 10	Cov	10	Beset by ice.
16	73 51 N.	15 40 W.	N.NW.	3	29.84	29.81	30	30.6	38.3	— 7.7	30	29.3		Cu., Ci	5.2	Midnight saw coast of Pendulum Island. (Hold with hope.)
17	73 43 N.	15 39 W.	W.	2	29.78	29.80	37	33.8	38.5	— 4.7	30	29.7		Cu., Ci	6.7	Warping.
18	73 36 N.	15 47 W.	S.SE.	1	29.97	29.95	31	30.6	39.0	— 8.4	30	30.0		Cu., Ci	9	Current of 9 to 10 miles in 24 hours.
19	73 34 N.	15 55 W.	NE.	6	29.77	29.75	33	34.5	39.2	— 4.7	30	29.7	S. 17	Cov	10	Warping.
20	73 20 N.	16 12 W.	NW.	5	29.94	29.95	34	33.1	39.6	— 6.5	30	29.7	S. 18	Cu., Str	5.3	Do.
21	73 11 N.	16 18 W.	Calm.	0	30.16	30.13	33	32.0	39.9	— 7.9	30	30.0	F. 5	Cir	6.2	Short tacks out of the ice.
22	73 4 N.	16 9 W.	N.NE.	1	30.03	30.04	31	32.4	40.3	— 7.9	31	30.9	F. 6	Cum	5.8	At 10 hours a.m. free of the ice. [8 miles.
23	73 31 N.	15 27 W.	S.	2	29.95	29.93	32	32.2	40.3	— 8.1	31	31.3	F. 3, S. 2	Cum	9	Backing along the eastern ice-barrier; made
24	74 13 N.	14 13 W.	E. by N.	3	29.81	29.83	35	33.6	40.3	— 6.7	32	31.8	F. 15	Cov	10	Sea dirty-green with transparent blue stripes.
25	74 12 N.	14 0 W.	NE.	6	29.72	29.72	34	35.0	40.1	— 5.1	31	31.8	F. 9	Ci., Cu	4	Off and on along the ice.
26	74 36 N.	13 55 W.	E.SE.	2	29.89	29.89	37	33.4	39.7	— 6.3	32	31.6	F. 9, R. 2	Cov	10	Sea dirty-green.
27	75 15 N.	12 52 W.	SE.	2	30.02	30.02	35	32.0	39.4	— 7.4	30	30.2	F. 24	Fog	10	240 fathoms, reddish clay with pebbles; 135 fathoms, the same bottom.
28	75 52 N.	12 11 W.	Calm.	0	30.05	30.02	35	32.9	38.7	— 5.8	29	30.6	F. 24	Fog	10	150 fathoms, same bottom; sea dark-green.
29	75 10 N.	11 47 W.	S.	4	29.75	29.74	33	33.1	39.6	— 6.5	31	32.6	F. 24	Fog	10	Sea dark-green, covered by a slimy substance.
30	75 8 N.	6 11 W.	S.	7	29.62	29.65	35	34.2	40.1	— 5.9	34	33.6	F. 24	Fog	10	First attempt for Spitzbergen.
July 1	75 2 N.	2 52 E.	W.NW.	6	29.84	29.81	34	33.4	40.1	— 6.7	34	34.5	S. 3	Cov	10	The sea gets bluish and transparent.
2	75 34 N.	9 17 E.	E. by S.	2	29.52	29.53	36	34.9	40.1	— 5.2	36	36.1	S. 2	Cov	10	The sea gets more blue and warmer; much sea-weed.
3	76 34 N.	15 52 E.	NW. by W.	2	29.42	29.44	33	34.7	38.7	— 4.0	32	33.8	S. 1	Cov	10	Drift-wood; saw Spitzbergen, (Sharkstooth Peak,) distance 20 miles.
4	76 3 N.	18 7 E.	N. by W.	4	29.43	29.41	35	33.1	39.8	— 6.7	32	32.0	S. 2	Cum	9	300 fathoms, mud and pebbles.
5	75 40 N.	22 59 E.	N. by E.	6	29.44	29.44	32	31.6	41.0	— 9.4	32	31.7	S. 6	Cum	9	Many soundings; entered the ice; deceptive appearance of land.

Abstract of the journal of the First German North Polar Expedition, 1868—Continued.

Date.	Position at noon.		Wind at noon.		Barometer.		Temperature of air.				Temp. of sea.		Hours of fog, rain, hail, and snow.	State of sky.		Notes.
	Latitude.	Longitude from Greenwich.	Direction.	Force 0 to 12.	At noon.	Daily mean.	At noon.	Daily mean.	Normal.	Difference.	At noon.	Daily mean.		Form.	Prop. obscured 1 to 10.	
	° ′	° ′			″	″	°	°	°	°	°	°				
July 6	75 38 N.	23 37 E.	N.NW.	5	29.57	29.62	34	33.1	41.4	— 8.3	32	32.0	S. 12	Ci., Str......	8	Thick ice; turned back.
7	75 39 N.	19 25 E.	W. by S.	3	29.86	29.87	35	36.0	41.4	— 5.4	34	34.5	F. 1...........	St., Ci., Cu.	6.5	Tacked along the ice; sounded in 85 fathoms, black clay.
8	75 29 N.	17 42 E.	Calm.	0	29.98	29.92	39	37.2	42.4	— 5.2	35	35.2	F. 1...........	Str., Cu.....	7.5	Surrounded by ice; many seal.
9	76 31 N.	13 42 E.	E.	9	29.49	29.50	37	37.2	39.9	— 2.7	40	40.6	R. 11..........	Cov.........	10	Two large icebergs; storm.
10	76 53 N.	13 50 E.	Calm.	0	29.42	29.46	36	34.9	39.6	— 4.7	32	32.9	F. 16..........	Cov.........	10	Drift-wood; whales; 100 fathoms, mud.
11	77 25 N.	14 10 E.	NW.	5	29.80	29.80	34	34.3	39.2	— 4.9	34	34.5	F. 6, R. 2.....	Cov.........	10	Close to the land, through the ice which gets less toward north.
12	77 21 N.	13 55 E.	Westerly.	1	29.85	29.86	36	36.5	39.4	— 2.9	36	35.6	F. 12..........	Ci., Str......	6	Some ice near the land; shore free; 30 fathoms, pebbles.
13	77 40 N.	13 27 E.	NW. by N.	2	29.92	29.94	40	36.7	39.7	— 3.0	36	36.0	F. 11..........	Ci., Str......	8	Anchored off Middlehook in 5 fathoms.
14	77 38 N.	14 53 E.	NW.	2	29.79	29.78	39	38.1	39.9	— 1.8	35	34.3	F. 12..........	Cov.........	10	Ascended Middlehook, and made other excursions.
15	77 38 N.	14 34 E.	Calm.	0	29.69	29.67	47	40.8	40.2	0.6	39	38.3	F. 4...........	Cum........	9	Calm; sea-tang; many grampus; long sea.
16	78 0 N.	11 39 E.	NE.	1	29.65	29.61	41	39.8	39.4	0.4	39	38.7	....	Cum........	9	Calm. [cold.
17	78 36 N.	8 5 E.	Easterly.	1	29.44	29.43	41	39.8	39.2	0.6	41	39.4	R. 1...........	Ci., Cu......	9	Sea blue and green, varying from warm to
18	80 30 N.	5 47 E.	SE. by S.	4	29.39	29.38	38	39.2	36.3	2.9	32	38.1	R. 3...........	Cov.........	10	Sea blue; some whales; sea-tang; near the ice.
19	80 13 N.	4 40 E.	N.NE.	3	29.35	29.37	37	36.1	36.7	— 0.6	39	34.7	F. 9, R. 3.....	Cov.........	10	No bottom at 400 fathoms; sea green.
20	79 15 N.	4 0 E.	N.	2	29.52	29.52	38	34.9	37.8	— 2.9	32	34.5	F. 17, R. 1, S. 1.	Cov.........	10	Second attempt for Greenland; much ice to westward.
21	77 40 N.	4 33 E.	N.	5	29.52	29.59	36	36.3	39.2	— 2.9	37	37.2	F. 5...........	Ci., Cu......	6	No ice in sight; sea blue; drift-wood.
22	76 17 N.	0 18 W.	NW.	1	29.63	29.62	39	37.6	41.4	— 3.8	37	37.4	F. 1...........	Ci., Cu......	6	No ice in sight; sea blue, with green stripes.
23	75 50 N.	2 51 W.	SW.	4	29.59	29.57	36	36.5	41.7	— 5.2	37	37.2	....	Ci., Cu......	5	Passed drift ice, then much ice with seal; sea green.
24	75 50 N.	7 2 W.	S.SW.	4	29.54	29.55	33	33.6	41.9	— 8.3	34	35.2	....	Ci., Cu......	5	Water blue and green; field-ice to the westward.

Notes 206. (Con'd.)

Note. 206. (Con'd.)

Abstract of the journal of the First German North Polar Expedition, 1868—Continued.

Date.	Position at noon. Latitude.	Position at noon. Longitude from Greenwich.	Wind at noon. Direction.	Wind at noon. Force 0 to 12.	Barometer. At noon.	Barometer. Daily mean.	Temperature of air. At noon.	Temperature of air. Daily mean.	Temperature of air. Normal.	Temperature of air. Difference.	Temp. of sea. At noon.	Temp. of sea. Daily mean.	Hours of fog, rain, hail, and snow.	State of sky. Form.	State of sky. Prop. obscured 1 to 10.	Notes.
	° ′	° ′			″	″	°	°	°	°	°	°				
July 25	75 25 N.	9 45 W.	SW.	5	29.56	29.53	39	36.3	41.9	— 5.6	37	35.0	F. 2	Cov	10	Great bight in the ice; worked in and out again.
26	75 3 N.	9 0 W.	W.SW.	3	29.42	29.48	37	35.8	41.9	— 6.1	37	36.3	F. 17	Cov	10	Ice to the southwest and northwest; refraction of the rays of the sun.
27	74 42 N.	11 26 W.	Calm.	0	29.72	29.75	43	36.7	42.1	— 5.4	37	35.4	...	Cir	3	Between drift-ice; sea green; no bottom at 400 fathoms.
28	74 34 N.	14 10 W.	SE.	1	29.85	29.81	37	33.8	42.3	— 8.5	34	33.1	...	Cir	3	In the ice; sea green.
29	74 20 N.	12 35 W.	S.	8	29.50	29.51	37	36.1	41.5	— 5.4	37	35.4	...	...	...	Laying-to on account of fog and rain.
30	74 10 N.	12 38 W.	S.SW.	1	29.46	29.46	41	38.1	41.7	— 3.6	37	36.1	...	Ci., St., Cu.	5	Do.
31	73 53 N.	12 5 W.	N.NE.	3	29.65	29.65	37	35.6	41.9	— 6.3	34	34.9	R. 6, F. 1	Cov	10	Sea bluish-green; in the ice.
Aug. 1	73 40 N.	11 58 W.	N.	2	29.70	29.68	34	33.8	42.1	— 8.3	36	34.0	F. 21	Cov	10	Sea green; thick ice.
2	73 35 N.	14 14 W.	NW.	5	29.46	29.52	34	32.7	41.9	— 9.2	32	32.2	F. 9	Cov	10	Field-ice to the west as far as the eye could reach.
3	73 19 N.	16 37 W.	SW.	3	29.74	29.70	34	34.7	41.4	— 6.7	32	32.2	S. 6	Ci., Cu.	5	Land in sight. Hold with hope to Cape James.
4	73 23 N.	17 21 W.	Calm.	0	29.80	29.75	37	31.1	41.1	— 10.0	33	32.0	F. 14	Cov	10	200 fathoms, soft clay; deep-sea temperature 33°.1.
5	73 25 N.	17 22 W.	NW.	2	29.73	29.72	38	34.9	41.4	— 6.5	33	32.0	F. 12	Cir	1	Thin, new ice.
6	73 23 N.	16 52 W.	W.	2	29.80	29.82	38	35.6	41.6	— 6.0	33	32.9	F. 2	Cir	2	Beautifully clear weather; in the ice.
7	73 20 N.	16 1 W.	SE.	2	29.86	29.87	37	36.2	41.6	— 5.4	35	34.7	...	...	0	No bottom at 400 fathoms.
8	73 8 N.	11 46 W.	N.NE.	8	29.88	29.87	38	37.0	41.2	— 4.2	38	37.8	F. 3, S. 1	Ci., Cu.	8	Attempt to reach Greenland in vain; out of the ice.
9	72 47 N.	9 31 W.	N.NE.	9	29.74	29.73	37	37.0	41.5	— 4.5	38	37.0	...	Cov	10	Second attempt for Spitzbergen.
10	72 22 N.	7 31 W.	N.	9	29.84	29.82	39	37.2	41.7	— 4.5	37	36.3	...	Cum	9	Shipping seas; sea blue.
11	72 30 N.	3 50 W.	N.	6	29.89	29.89	36	36.0	41.4	— 5.4	36	36.3	...	Cum	10	Sea bluish-green; high seas from the east.
12	72 33 N.	2 7 W.	NE. by N.	3	29.99	29.98	36	35.8	42.3	— 6.5	37	36.7	R. 3	Cum	9	Sea dark and light-green.
13	73 15 N.	3 10 W.	N.NE.	3	29.97	30.00	37	36.0	40.1	— 4.1	37	36.7	R. 1, F. 2	Cum	9	A knotty piece of drift-wood.

Abstract of the journal of the First German North Polar Expedition, 1868—Continued.

Date.	Position at noon. Latitude.	Position at noon. Longitude from Greenwich.	Wind at noon. Direction.	Wind at noon. Force 0 to 12.	Barometer. At noon.	Barometer. Daily mean.	Temperature of air. At noon.	Temperature of air. Daily mean.	Temperature of air. Normal.	Temperature of air. Difference.	Temp. of sea. At noon.	Temp. of sea. Daily mean.	Hours of fog, rain, hail, and snow.	State of sky. Form.	State of sky. Prop. obscured 1 to 10.	Notes.
	° ′	° ′			″	″	°	°	°	°	°	°				
Aug. 14	73 51 N.	1 43 W.	NW.	3	30.22	30.22	36	36.3	40.1	— 3.8	38	37.4	F. 4, R. 1.....	Cum	9	Sea blue ; drift-wood.
15	75 36 N.	0 6 W.	SW.	6	30.23	30.20	37	37.0	38.6	— 1.6	38	38.1	S. 1	Cu., Str.....	10	Do.
16	77 37 N.	4 48 W.	S.SW.	6	30.02	30.02	37	37.8	36.5	1.3	39	39.2	R. 13.........	Nim.........	10	Sea blue, then varying from blue to green.
17	79 6 N.	10 6 W.	S.SW.	4	29.97	29.96	38	37.2	35.9	1.3	38	38.3	R. 5..........	Ci., Cu......	8	Prince Charles Foreland in sight.
18	80 0 N.	14 17 W.	NW.	2	30.01	30.01	35	34.5	34.7	— 0.2	37	36.7	F. 2, S. 3......	Ci., Cu......	7	Many soundings ; pebbles and shells.
19	80 5 N.	17 30 W.	SE.	7	29.93	29.86	35	34.7	34.7	0.0	34	34.5	....	Ci., Cu......	8	Off Moffen, then to Henlopen Straits.
20	79 57 N.	17 8 W.	SE. by E.	6	29.69	29.73	37	36.7	34.7	2.0	34	34.5	S. 2, F. 2......	Ci., Cu......	8	Much drift-ice.
21	79 30 N.	20 1 W.	NW. by N.	2	29.92	29.91	37	34.9	34.7	0.2	34	34.0	....	Cov.........	10	Calm in the Straits, outside fresh northwest wind ; drift-ice.
22	79 20 N.	21 27 W.	W.	1	29.96	29.97	32	32.5	34.5	— 2.0	33	32.9	F. 12, S. 2.....	Ci., Cu......	6	Bay-ice in the bights.
23	79 20 N.	20 52 W.	....	1	30.04	30.06	29	27.1	34.5	— 7.4	32	31.5	....	Cov.........	8	Calm under the lee of Cape Torrell ; flood and ebb-tide southeast and northwest.
24	....	....	....	0	30.03	30.02	28	27.3	34.5	— 7.2	31	31.5	S. 1	Cov.........	10	Under sail, seeking shelter from the drift-ice and wind.
25			E.	7	29.99	29.97	27	26.1	34.2	— 8.1	31	31.5	S. 5	Cov.........	10	Temperature at the glacier, 3 p. m., 25°.2.
26	....	....	N.NW.	4	29.79	29.80	32	30.0	34.2	— 4.2	33	32.7	S. 3	Cum	9	Firm ice to the east and east-southeast.
27	....	....	Calm.	0	29.85	29.88	35	31.3	34.2	— 2.9	32	31.7	....	Cum	9	Little ice in the Straits.
28	....	....	Calm.	0	29.94	29.94	33	30.6	34.0	— 3.4	31	31.3	....	Cu., Str.....	6	Calm.
29	....	....	Calm.	0	30.03	30.01	35	33.0	34.0	— 1.0	32	32.0	....	Ci., Cu......	5	Often beautifully clear ; the range of mountains distinctly visible.
30	....	....	Calm.	0	29.96	29.81	33	30.6	34.0	— 3.4	32	30.9	....	Cov.........	10	Black clay between Capes Torrell and Waigat.
31	....	....	S.	2	29.95	29.96	31	30.6	33.8	— 3.2	32	32.2	....	Cum	9	Soundings ; soft clay and coarse sand.
Sept. 1	79 3 N.	21 2 W.	N.	6	29.81	29.80	35	33.8	33.8	0.0	32	32.0	....	Cov.........	10	Fog ; drift-ice. [tent of ice.
2	....	....	S.	3	29.76	29.81	36	34.2	33.8	0.4	33	33.1	R. 6, S. 4	Ci., Cu......	6	Ascended the mountain to ascertain the ex-
3	....	....	Calm.	0	29.93	29.89	36	33.8	33.6	0.2	33	32.9	F. 16.........	Cov., Fog ..	10	Discovery of Bismarck Straits.
4	79 3 N.	21 2 W.	Variable.	1	29.81	29.82	37	36.3	33.6	2.7	33	33.1	F. 23.........	Cu., Fog....	9	Sailed around King William's Island.

Note. 206. (Con'd.)

Note. 206. (Con'd.)

Abstract of the journal of the First German North Polar Expedition, 1868—Continued.

Date.	Position at noon. Latitude.	Position at noon. Longitude from Greenwich.	Wind at noon. Direction.	Wind at noon. Force 0 to 12.	Barometer. At noon.	Barometer. Daily mean.	Temperature of air. At noon.	Temperature of air. Daily mean.	Temperature of air. Normal.	Temperature of air. Difference.	Temp. of sea. At noon.	Temp. of sea. Daily mean.	Hours of fog, rain, hail, and snow.	State of sky. Form.	State of sky. Prop. obscured 1 to 10.	Notes.
	° '	° '			"	"	°	°	°	°	°	°				
Sept. 5	....	....	N.	1	29.86	29.85	37	35.7	33.4	1.3	33	32.9	F. 4..........	Cov., Fog ..	9	Annoying drift-ice.
6	....	....	SE.	2	29.70	29.69	33	32.9	33.4	— 0.5	32	32.0	F. 4..........	Cov., Fog ..	10	Drift-ice accumulating in the bay; German Bight.
7	....	....	E.SE.	6	29.52	29.47	34	33.8	33.2	0.6	32	32.0	R. 16, F. 12, S. 12	Cov........	10	Stormy; much drift-ice.
8	....	....	SE.	5	29.35	29.34	35	33.1	33.1	0.0	32	32.0	F. 12, R. 16, S. 8	Cu., Fog....	9	Calm and fog.
9	....	....	Calm.	0	29.45	29.47	34	32.7	33.1	— 0.4	32	32.2	F. 4..........	Ci., Cu......	8	Clear, then snow; young ice.
10	....	....	Calm.	0	29.57	29.54	34	32.7	32.9	— 0.2	32	32.2	F. 2, S. 2......	Cov........	10	Starting for the north.
11	79 39 N.	18 20 W.	NW. by N.	4	29.56	29.55	31	31.1	32.9	— 1.8	33	33.1	S. 19..........	Cov........	10	Snow; drifting considerably.
12	80 2 N.	16 56 W.	N.NW.	6	29.65	29.67	32	30.4	32.0	— 1.6	37	35.1	S. 24..........	Cov........	10	No drift-ice, but glacier-ice.
13	80.10 N.	14 40 W.	N. by W.	5	29.83	29.83	29	29.5	31.5	— 2.0	35	34.9	S. 19..........	Cov........	10	At 120 fathoms, no bottom; 52 fathoms, mud.
14	80 42 N.	15 57 W.	W.	1	30.05	30.04	30	29.8	31.1	— 1.3	36	35.8	F. 1..........	Ci., Cu......	7	85 fathoms, mud and pebbles; ice on the horizon.
15	80 16 N.	13 37 W.	S.SE.	6	29.80	29.81	33	32.7	31.6	1.1	37	37.0	F. 4..........	Cum.......	8	Thick ice to the west and northwest.
16	80 14 N.	7 24 W.	S.SW.	6	29.68	29.68	33	33.1	31.8	1.3	40	38.7	S. 4..........	Ci., Cu......	8	65 fathoms, pebbles; snow-drifts.
17	78 58 N.	8 10 W.	NW.	6	30.03	30.04	29	30.2	32.7	— 2.5	35	38.5	S. 12..........	Cov........	10	Sea bluish-green; homeward bound.
18	77 17 N.	7 03 W.	W.	1	30.20	30.14	31	31.7	34.7	— 3.0	39	37.6	....	Cov........	10	Sea blue and shining; high seas from west-southwest.
19	76 35 N.	5 19 W.	S.	2	29.82	29.86	34	34.0	34.9	— 0.9	37	37.0	R. 1, S. 2.....	Cov........	10	Snow and rain.
20	74 55 N.	4 42 W.	N. by E.	5	30.12	30.12	34	32.9	35.8	— 2.9	37	36.5	S. 4..........	Cum.......	9	Clearing off; transparent air; sea blue; drift-wood.
21	73 15 N.	3 17 W.	W.	1	30.37	30.36	32	31.1	38.3	— 7.2	37	36.5	S. 1..........	Cov........	10	Seas from the north; snow.
22	72 40 N.	3 17 W.	Variable.	1	30.30	30.26	35	35.4	38.8	— 3.4	39	38.3	S. 5, F. 2......	Cov........	10	Short seas from the southwest; sea blue; clear in the north, but thick in the east and northeast.
23	71 40 N.	3 16 W.	NE. by N.	7	30.21	30.21	39	38.8	39.4	— 0.6	43	42.1	R. 6..........	Cum.......	7	Storm.
24	69 1 N.	1 18 W.	E.NE.	8	30.28	30.23	41	41.1	42.6	— 1.6	46	47.7	R. 3..........	Cu., Ni.....	8	Storm; strong aurora borealis from 9 to 11 p.m.

Note. 206. (Con'd.)

Abstract of the journal of the First German North Polar Expedition, 1868—Continued.

Date.	Position at noon.		Wind at noon.		Barometer.		Temperature of air.				Temp. of sea.		Hours of fog, rain, hail, and snow.	State of sky.		Notes.
	Latitude.	Longitude from Greenwich.	Direction.	Force 0 to 12.	At noon.	Daily mean.	At noon.	Daily mean.	Normal.	Difference.	At noon.	Daily mean.		Form.	Prop. obscured 1 to 10.	
	° ′	° ′			″	″	°	°	°	°	°	°				
Sept. 25	66 9 N.	0 27 E.	NE.	8	30.04	30.06	45	44.4	46.9	— 2.5	49	48.4	R. 2	Ni., Cu	8	Storm.
26	63 30 N.	1 34 E.	E.NE.	7	29.92	29.92	46	46.4	49.3	— 2.9	50	50.4	....	Cum	9	Sea green.
27	61 41 N.	3 24 E.	E.	2	29.87	29.82	52	49.5	49.1	0.4	53	32.5	....	Ci., Cu......	6	Beautifully clear; strong aurora up to the zenith.
28	60 46 N.	4 16 E.	E.	2	29.46	29.41	51	50.9	48.7	2.2	54	54.5	R. 3..........	Cov.........	10	Violent rain; stiff breeze.
29	60 36 N.	4 53 E.	NW.	2	29.33	29.24	53	52.0	48.4	3.6	54	54.3	R. 14..........	Nim	8	Arrival at Bergen.

Notes.

207-8. [207] These are but hypothetical values, not founded upon actual observations. We, on the contrary, believe in the extension of the Gulf Stream to Spitzbergen, even in winter.

A. PETERMANN.

208. [208] The following is a table of the deep-sea soundings by the First German North Polar Expedition, 1868:

Number.	Date.		Position. Latitude.	Long. from Greenwich.	Depth in fathoms.	Description of the specimen of bottom.
			° ′	° ′		
1	June	27	75 15 N.	12 30 W.	240	Reddish clay with a few pebbles of grayish-black granite.
2	June	27	75 44 N.	12 11 W.	135	Grayish-red clay without pebbles.
3	June	27	75 52 N.	12 11 W.	150	Do.
4	July	3	76 36 N.	15 52 E.	300	Gray clay and pebbles.
5	July	4	75 59 N.	18 55 E.	85	Fine gray clay with white pebbles.
6	July	4	76 03 N.	19 47 E.	50	Shells and pebbles.
7	July	4	75 58 N.	20 14 E.	30	Yellowish-red shells, black (granite) and red round pebbles.
8	July	4	75 54 N.	20 40 E.	22	
9	July	5	75 51 N.	20 25 E.	22	
10	July	5	75 48 N.	21 09 E.	21	The same, but finer, especially the black pebbles.
11	July	5	75 46 N.	21 34 E.	22	Do.
12	July	5	75 43 N.	21 59 E.	25	Light-yellow shells, without pebbles.
13	July	5	75 42 N.	22 29 E.	26	Light-yellow shells, somewhat finer.
14	July	5	75 40 N.	22 59 E.	30	Grayish-yellow shells and gray pebbles with sharp edges.
15	July	5	75 45 N.	22 57 E.	25	Fine grayish-yellow shells and black, smooth pebbles.
16	July	5	75 45 N.	23 24 E.	45	Fine gray clay.
17	July	6	75 38 N.	23 24 E.	30	Gray clay, coarser.
18	July	6	75 32 N.	22 26 E.	31	Coarse yellow shells, thick.
19	July	6	75 20 N.	21 13 E.	25	Pretty fine yellow shells and black, round pebbles.
20	July	7	75 39 N.	19 48 E.	40	Coarse yellow shells, thick.
21	July	7	75 33 N.	19 02 E.	45	Fine variegated gravel, yellow shells, and stones.
22	July	12	77 21 N.	14 04 E.	35	Black round pebbles, (granite.)
23	August	3	73 17 N.	17 40 W.	250	Gray clay with a large stone.
24	August	5	73 23 N.	17 22 W.	140	Fine granular clay.
25	August	5	73 25 N.	17 22 W.	170	Do.
26	August	17	79 11 N.	10 06 E.	22	Yellow shells, black and carmine pebbles.
27	August	17	79 44 N.	10 22 E.	32	Yellow shells, (at Hackluyt.)
28	August	17	79 52 N.	11 08 E.	7	Coarse gray granite.
29	August	17	79 58 N.	11 46 E.	33	Fine pebbles and shells.
30	August	18	79 59 N.	11 52 E.	28	Yellow shells.
31	August	18	80 00 N.	13 02 E.	80	Evenly fine, gray clay.
32	August	18	80 00 N.	13 53 E.	80	Do.
33	August	18	80 00 N.	14 08 E.	44	Shells and clay.
34	August	30	79 19 N.	20 52 E.	36	Black clay and loam.
35	August	30	79 19 N.	21 00 E.	31	Loam and coarse stones.
36	August	30	79 19 N.	21 06 E.	28	Whitish clay and shell fragments.
37	September	13	80 21 N.	15 33 E.	52	Fine gray clay.
38	September	13	80 39 N.	16 57 E.	55	Do.
39	September	14	80 16 N.	13 37 E.	85	Do.

Note. 208. (Con'd.)

The following soundings were without results:

Number.	Date.	Position.		Depth in fathoms.	Description of the specimen of bottom.
		Latitude.	Long. from Greenwich.		
		° ′	° ′		
	May 26	63 56 N.	00 04 E.	290	No bottom reached.
	July 6	75 38 N.	23 37 E	200	Do.
	July 17	79 16 N.	06 02 E.	400	Do.
	July 28	74 34 N.	14 10 W.	400	Do.
	September 12	80 14 N.	16 18 E.	120	Do.
	September 13	80 46 N.	16 52 E.	120	Do.

Professor Ehrenberg, to whom the specimens of the bottom brought home by the expedition were sent for examination, made, in the session of the Berlin Academy of December 10, 1868, the following remarks in regard to them:

"I cannot yet report in detail on the scientifically interesting character of these 39 specimens, but, as other similar expeditions are in prospect, I would earnestly recommend that they be provided with the proper apparatus for bringing up such specimens from greater depths, as the general impression that the Northern Sea is, in the main, but shallow, is probably erroneous. The knowledge of the bed of the Polar Sea will obtain a broader foundation only when we succeed in bringing up specimens not despoiled by the tallow now used for raising them. The much spoken of apparatus of Brooke, and the more capacious now in use on British, Swedish, and Russian ships of war, will promote the cause.

"At present this valuable material must first be freed from the tallow mixed up with it, before the very minute forms of life found in the Polar seas can be specified with any certainty. The entire collection by the German expedition has the great scientific advantage that the depths at which they were obtained not, being very great, are sure, while greater depths are frequently uncertain.

"The enumeration of all the small species of forms found in the bed of the sea, and constituting it, is, however, not the most important object of research; it is of far greater moment to establish more firmly whether the six classes of smallest, to the naked eye invisible, independent organic forms and fragments of such, which have already been adopted in microgeology, and which thus far have exclusively been found under all the relations of the planet, viz:

"1. Polythalamia, as independent calcareous crustacea;

"2. Zoolitharia, as dependent fragments of radiata and corals;

"3. Polyastric bacillaria and

"4. Polycystina, as independent siliceous crustacea;

"5. Phytolitharia and

"6. Geolithia, as organic siliceous vegetable fragments,

are also existing, without or with other components, in the Polar zone, and so to reach final results in this branch of the exploration of the relations of organic life in nature.

"According to the preliminary report of Professor Nordenskiöld, (in the Geographische Mittheilungen for 1868, p. 429,) on the results of the contemporaneous labors of the Swedish expedition, these also did not extend beyond lati-

Notes.

208-9. tude 81° N. They appear, however, to have been extraordinarily successful as regards the better knowledge of Spitzbergen and Bear Island; and the deep-sea soundings, with the specimens of bottom brought up from depths of 1,350 and 2,000 fathoms, will contribute materially to the accurate knowledge of the bed of the sea; they have also proved by direct observation that the assumption of the Northern Sea being shallow is incorrect.

"If Captain Koldewey has not obtained bottom from great depths, the 39 specimens brought home appear to convey very sure data for conclusions in regard to the current-relations in the regions visited by the Greenland. In 22 of the soundings muddy bottom was found, while by the other 17 casts coarser débris and rolling matter without any mud was brought up. It may be inferred from this that there exists in the latter 17 places at the bottom a current which prevents the finer particles of the matter, sinking down successively, from settling quietly, and rounds off the stony elements. Reversedly, and supposing that the lead did not accidentally fall into a funnel-shaped hole, it may be concluded that immediately over each of the 22 specimens, consisting of fine dust or mud, the sea must have been completely at rest, as otherwise the fine dust could not have quietly settled and augmented there. In regard to the mud itself, I will only state preliminarily that the few examinations made thus far have exhibited a not inconsiderable admixture of organic forms, for the greater part spongolithæ and single phytolitharia.

"The 17 specimens which contain rolling stones of sufficient weight to resist a weak motion, and which therefore indicate a ground current, are the numbers 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 18, 19, 22, 26, 27, 28, and 33.

"The reef between Spitzbergen and Bear Island, to its sudden plunge to the southwest, may be compared in certain respects with the Newfoundland Banks, where likewise the conflict of the Gulf Stream with the Polar stream appears to be the cause of the great deposits."

209. [209] This movement of the waters and of the ice has been observed already by Barents 1596 to 1597, and Admiral Lütke confirms that a current from the south flows west of Nova Zembla, and a counter-stream from the east, north of the island. On his last voyage homeward-bound he traced the ice-barrier in latitude 75½° N. to longitude 44° E. of Greenwich.

Hedenström also records that farther east along the coast of New Siberia the sea is in March free of ice. Middendorf reached Cape Taymir through an open sea.

Parry encountered the first ice on May 5th in latitude 73½° N., longitude 7½° E., W. S. W. of Bear Island. It extended in long unbroken strips more than 100 miles in a N. N. W. direction.

A Russian, Staratschin, who lived in Spitzbergen for 15 years uninterruptedly, sailed four times around the entire island, failing twice in the attempt. He believes the coast from S. E. to N. E. to be free of ice for four to five months of the year; (but how far?)

Notes. 210-11.

210 *Deep-sea temperatures observed by the First German North Polar Expedition*, 1868.

Time.		Position.		Depth in fathoms.	Temperature.		
Month and day.	Hour.	Latitude.	Longitude from Greenwich.		Of the sea at the depth.	Of the sea, at the surface.	Of the air.
		° ′	° ′		°	°	°
May 25	0	61 57 N.	1 29 E.	50	47.8	47.8	48.7
26	0	63 56 N.	0 04 E.	70	47.8	47.3	50.4
26	4	64 11 N.	0 08 W.	60	47.8	47.3	50.0
26	12	64 36 N.	0 38 W.	75	45.5	45.5	47.1
26	16	64 46 N.	0 45 W.	80	41.0	44.6	45.5
26	16	64 46 N.	0 45 W.	60	42.1	44.6	45.5
27	12	66 04 N.	2 02 W.	55	39.4	42.5	44.4
27	12	66 04 N.	2 02 W.	30	41.1	42.5	44.4
28	8	67 21 N.	0 37 W.	55	38.7	42.1	41.0
28	16	67 58 N.	0 54 W.	45	38.7	41.4	36.5
31	10	70 25 N.	3 12 W.	30	34.5	36.0	30.9
31	12	70 29 N.	2 37 W.	30	35.4	35.4	34.7
31	18	70 40 N.	2 17 W.	50	37.6	38.7	34.7
June 1	0	70 30 N.	2 15 W.	40	37.8	38.7	34.7
July 18	0	80 38 N.	6 40 W.	100	37.1	(ice) 32.0	37.8
August 3	21	73 25 N.	17 18 W.	170	33.1	32.0	32.0
September 13	16	81 00 N.	16 11 E.	50	35.4	34.2	29.3
17	18	77 16 N.	7 04 E.	80	36.7	36.9	30.4
21	4	73 10 N.	3 19 E.	100	32.0	36.0	31.1
22	0	72 34 N.	3 24 E.	60	32.0	38.7	36.1
22	2	72 25 N.	3 21 E.	40	37.6	38.9	36.1
22	22	71 55 N.	3 23 E.	40	38.5	41.5	37.1
23	0	71 40 N.	3 16 E.	60	39.8	43.0	38.5
24	2	68 48 N.	1 18 E.	60	43.0	46.2	42.3

211 Very similar conclusions must be drawn from the following table of deep-sea temperatures kindly sent me by Professor Mohn. They are from the journal of the steamer Hansteen, and are the more valuable, because obtained within the limits of but a small area, the West Fiord on the coast of Norway: 211.

Date.	Position.		Temperature.		Depth in fathoms.	Decline of temperature for each 10 fathoms—deduced.
	Latitude north.	Longitude east of Greenwich.	Of the surface of the sea.	At the depth recorded in the next column.		
1868.	° ′	° ′	°	°		°
July 7	68 10	14 45	51.4	45.7	320	0.18
16	68 00	13 35	50.0	45.5	60	0.76
18	68 00	13 35	50.4	45.3	65	0.78
27	68 00	13 30	50.4	45.3	82	0.61
28	68 00	13 30	51.1	45.0	150	0.41
29	68 00	13 30	57.2	45.0	85	1.44
August 4	67 50	14 40	53.6	44.6	240	0.38
5	68 10	14 15	54.3	44.6	160	0.61
7	68 10	14 15	55.8	43.5	94	1.30
20	67 50	13 30	54.3	45.0	146	0.65
22	67 50	13 30	54.7	44.6	221	0.45
September 12	67 50	14 25	51.4	45.3	180	0.34
Mean						0.70
The observations in latitude 67° 50′ by themselves would give						0.45
The observations in latitude 68° 00′ by themselves would give						0.79
The observations in latitude 68° 10′ by themselves would give						0.70

Notes.

211-14. In deducing the mean of the total the first observation has been rejected, because the lead had reached probably near the bottom.

* * * * * * *

212. [212] The following is a recapitulation of the sleigh expeditions, according to the Geographische Mittheilungen, 1868, No. 5:

Captain McClintock, 1,220 miles in 105 days.
Captain G. Richards, 1,012 miles in 102 days.
Lieutenant Mecham, 1,203 miles.
Captains Richards and Osborn, 1,093 miles.
Lieutenant Hamilton, 1,150 miles, with only one companion in a dog-sleigh.
Lieutenant Mecham, 1,157 miles in 70 days.
Lieutenant Young, 1,150 miles.
Captain McClintock, 1,330 miles.
Commodore Parry, 1,127 miles in 67 days.

213. [213] Short account of the principal expeditions to the sea north of Spitzbergen:

1773. Phipps cruised the entire summer, to the 20th of August, north of Spitzbergen without being able to reach the parallel of latitude 81° N. He saw field-ice as far as his eye could reach; his account of it caused Parry's expedition in sleigh-boats.

1818. Buchan and Franklin repeated the attempt, but did not go farther than 80° 30′ N. The ice was high and close, without a navigable opening.

Scoresby visited the waters of Spitzbergen for many years, but reached only once to latitude 81° 30′ N., and could not penetrate higher, although he saw saw a considerable opening in the ice extending from east to west.

1827. Parry attempted to push, in sleigh-boats, from Spitzbergen to the North Pole. He traveled on broken ice pressed firmly together to latitude 82° 45′ N., reaching there the 23d July, but could not see there any indication of open water toward the north. On the return he did not come to navigable water before reaching latitude 81° 34′ N.

1861. Torell and Nordenskiöld ascended the Snötoppen (snow-summit) on the Northeastland, 1,900 feet high, but could not detect any signs of open water north of the Seven Islands. (From the memoirs of the Swedish expedition of 1864, supplement No. 16 to the Geographische Mittheilungen.)

214. [214] The daily amplitude of the air will be seen from the following:

Table of mean temperatures.

Month.	0 hrs.	4 hrs.	8 hrs.	12 hrs.	16 hrs.	20 hrs.	Places.
	°	°	°	°	°	°	
May	43.79	43.05	42.49	40.96	40.80	41.43	On the way north.
June	32.77	33.08	33.06	32.36	32.38	32.36	In the ice near Greenland.
July	37.26	36.52	35.06	35.92	35.22	36.36	Spitzbergen reef and open sea west of Spitzbergen.
August	34.97	35.28	33.71	32.16	32.18	33.49	Off Greenland, to the north, and Hinlopen Straits.
September	36.52	36.81	36.03	35.94	35.76	36.12	Hinlopen Straits and home voyage.
Mean	37.06	36.95	36.25	35.46	35.26	35.96	

Notes.

This method of arriving at means may meet disapproval; it was, however, the only one available; there is no doubt of the insignificance of the fluctuation. 214-15.

In close connection with this uniformity of the temperature is the rarity of thunder-storms in high latitudes. Von Baer reports that "in Nova Zembla and in Spitzbergen thunder is sometimes heard," but according to the testimony of Scoresby, Parry, Ross, Franklin, and others, it cannot be doubted that, in general, electric explosions are of extremely rare occurrence between the parallels of latitude 70° and 75° N. Compare also Humboldt's Kosmos, i, p. 364. The German expedition also has observed none in higher latitudes.

Absolute extremes of temperature.

Month.	Air.		Sea.	
	Maximum.	Minimum.	Maximum.	Minimum.
	°	°	°	°
May	On the 24th, 52.2	On the 31st, 29.6	On the 25th, 49.3	On the 31st, 32.0
June	On the 19th, 37.6	On the 4th, 25.2	On the 1st, 38.8	On the 15th, 28.6
July	On the 15th, 46.6	On the 24th, 30.4	On the 9th, 42.1	On the 3d, 30.6
August	On the 5th, 41.0	On the 25th, 24.4	On the 17th, 41.7	On the 31st, 29.8
September	On the 29th, 53.8	On the 12th, 28.2	On the 28th, 54.7	On 1st, 7th, & 8th, 32.0

[215] The following is a register of the winds arranged by months: The unit of time is the watch, (one watch as regulated on ship-board being = 4 hours;) the figures in brackets indicate the storms; besides these, the hours of fog, rain, and snow, and the extent of the clouds are enumerated. N. B. North = North + $\frac{1}{2}$, (N. by E. + N. by W.,) &c.: 215.

Note.
215.
(Con'd.)

Register of the winds.

Month.	N.	N.NE.	NE.	E.NE.	E.	E.SE.	SE.	S.SE.	S.	S.SW.	SW.	W.SW.	W.	W.NW	NW.	N.NW.	Calms.	Total.
MAY, (seven days.)																		
Winds.................watches..	1	2 (2)	2 (2)	2 (2)	2 (1)	2	2	11	3 (1)	2 (1)			1	3	2	1	1	41 (9)
Force, (according to Beaufort)....	7	17	16	16	15	13	26	40	14	10			3	15	10	6		208
Fog.....................hours..															4	2	4	8
Rain ....hours..			8	8	8	4	4	6	2									42
Snow ....hours..		2	4															6
Cloudiness........................	10	9	20	20	20	20	41	73	20	10			8	28	18	10	10	317
JUNE.																		
Winds.................watches..	27	7	12 (1)	8 (1)	18 (2)	8 (1)	11	15	16 (2)	6	8		5	5	6	12 (1)	16	180 (10)
Force, (according to Beaufort)....	143	26	43	30	62	24	41	58	45	13	23		19	30	22	48		627
Fog.....................hours..	14	9	14	18	45	21	16	13	36		12		4			6	30	238
Rain ....hours..				2	1		2	2										7
Snow ....hours..	40	5	5	8	12	8	17	9					1	2	4	12		123
Cloudiness........................	251	68	111	72	171	80	106	107	137	56	63		47	45	49	105	119	1,567
JULY.																		
Winds.................watches..	18 (1)	14	5	1	8 (2)	7	11	4	9 (2)	12	11	5	7	5	23 (1)	23 (1)	23	186 (7)
Force, (according to Beaufort)....	72	33	14	1	35	12	46	6	49	48	50	12	21	21	56	84		560
Fog.....................hours..	14	2				7	12	1	13	9	4	6	4		18	15	28	133
Rain ....hours..		7	2		1	3	1				1				2			17
Snow ....hours..	15	1			4						1					12	2	35
Cloudiness........................	193	111	44	7	77	64	104	40	50	56	101	39	59	47	180	135	212	1,519
AUGUST.																		
Winds.................watches..	25 (7)	19 (10)	5		1	5 (3)	20 (1)	2	13	10	5	1	7	4	18	12	39	186 (21)
Force, (according to Beaufort)....	121	125	9		7	35	54	8	39	44	13	6	15	12	46	43		577
Fog.....................hours..	4	3	12			2	5	2	8		4		1	2	10		11	64
Rain ....hours..	2	3							1	2					1			9
Snow ....hours..	1	1			4	3	3		2		1			7	1		2	25
Cloudiness........................	197	166	47		10	44	140	15	72	54	26	10	48	38	112	114	248	1,341

Note. 215. (Con'd.)

Register of the winds—Continued.

Month.	N.	N.NE.	NE.	E.NE.	E.	E.SE.	SE.	S.SE.	S.	S.SW.	SW.	W.SW.	W.	W.NW	NW.	N.NW.	Calms.	Total.
SEPTEMBER.																		
Winds..................watches..	12	4	16 (2)	18 (2)	14 (4)	8	10	5	11	3	5	1	8	3	7	17	38	180 (6)
Force, (according to Beaufort)....	61	22	93	109	66	28	30	19	33	13	13	1	20	14	29	85	....	636
Fog......................hours..	3	....	4	8	8	4	8	4	....	....	4	....	....	2	2	....	44	91
Rain......................hours..	2	2	3	24	21	5	10	4	3	....	1	....	....	....	....	....	16	91
Snow......................hours..	27	....	....	12	8	1	9	1	5	4	2	....	4	2	9	32	10	116
Cloudiness........................	100	39	135	157	119	60	85	40	100	21	40	10	56	30	61	185	337	1,548
TOTAL.																		
Winds..................watches..	83 (10)	46 (12)	40 (5)	29 (5)	43 (9)	30 (4)	58 (1)	37	52 (5)	33 (1)	29	7	28	20	56 (1)	65 (2)	117	773 (55)
Average force....................	4.9	4.8	4.4	5.4	4.3	3.7	3.4	3.5	3.5	3.9	3.4	2.7	2.8	4.6	2.9	4.1	....	3.4
Fog......................hours..	35	14	30	26	53	34	41	20	57	9	24	6	....	4	34	21	117	534
Rain......................hours..	4	12	13	34	31	12	17	12	6	2	2	....	5	....	3	2	16	166
Snow......................hours..	73	9	9	20	28	12	29	10	7	4	4	....	....	11	14	56	14	305
Average cloudiness..............	8.8	8.5	8.9	8.8	9.2	8.9	8.2	7.4	7.3	6.0	7.9	8.4	7.8	9.4	7.5	8.0	3.0	8.1

Note. 215. (Con'd.)

Thus the sum of all the watches, during which observations were made, of four hours each, is	773
The aggregate force (according to Beaufort) of all the winds, the calms included	2,608
The average force, therefore, of winds, including calms	3.4
Sum total of all the calms, (watches)	117
Sum total of all the winds really, (watches)	656
Their aggregate force	2,608
The average force of the winds really	4.0
Of the winds there were gales	55
Their average force was	8.4
Proportion of the watches to calms	100 to 15
Proportion of the watches to gales	100 to 7
Proportion of the watches to fogs of 4 hours' duration	100 to 17
Proportion of the watches to rains of 4 hours' duration	100 to 5
Proportion of the watches to snows of 4 hours' duration	100 to 10
Watches with a clear sky	19
And their proportion to the whole number	100 to 2.5

There were consequently in 100 watches, or 400 hours; 17 watches or 68 hours of fog; 5 watches or 20 hours of rain; 10 watches or 40 hours of snow; 2.5 watches or 10 hours of clear sky; 78 watches or 312 hours of light to stiff breezes; 7 watches or 28 hours of gales; and 15 watches or 60 hours of calms.

The prevailing direction of the wind in general is northerly; the mean direction for the entire region traversed by the ship, deduced according to Lambert's formula, is N. 31° E.

The quarter from which most of the winds blew is that from N. N. W., through N. to S. E. There were from N. N. W. 65 winds, against 37 from S. S. E.; from the N. 83, against 52 from the south; from N. N. E. 46, against 33 from S. S. W.; from N. E. 40, against 29 from S. W.; from E. N. E. 29, against 7 from W. S. W.; from the east 43, against 28 from the west; from E. S. E. 30, against 20 from W. N. W.; and from S. E. 58, against 56 from N. W.

The gales also came in the greater part from a northerly and easterly direction; there were from the N. W., 1; N. N. W., 2; N., 10; N. N. E., 12; N. E., 5; E. N. E., 5; E., 9; E. S. E., 4; S. E., 1; S., 5; S. S. W., 1.

They come often very suddenly, especially those from a southeasterly direction, (at Bear Island and in Hinlopen Straits), last but a short time, and are, without exception, followed by calms. Those of longer duration blow from east to north. Changes of the wind were observed:

Against the sun 15 times in stormy weather,
With the sun 6 times in stormy weather,
Against the sun 10 times in moderate weather,
With the sun 6 times in moderate weather.

Between these changes there were 27 complete calms and 7 baffling winds.

The following is recorded in detail, in regard to the winds and the weather, for the several months and various localities:

In May, after starting from Bergen on the passage north, there were for the first days fresh southerly breezes, followed by the first severe gale from E. to N. N. E., which prevented the passage to Jan Mayen. It brought much rain, of which there was more during the 8 days of May than in the succeeding three summer months, (42 hours against 33); during the rain, in May as well as in the three summer months, the wind came from the southern quarter by the E. to N. E.; in September, also, the rain, then twice as copious, was accompanied by winds from the N. E. and S. E. quarters, as there was to the west only ice and land, and to the east the warm sea. The average force of the wind in May was 5. Note. 215. (Con'd.)

The little fog in May comes from the ice to the N. W.; the snow from N. N. E. and N. E.; the proportion of the covered sky was in the average 7.7.

Nearly throughout all of June the ship was, with the exception of the three first days, off the Greenland coast, where she was beset by the ice for 13 days. It blew 118 watches from the quarter N. N. W. through N. to S. S. E., and only 46 watches from the S. S. E. by the S. to N. N. W., consequently twice as often from an easterly as from a westerly direction; between these winds were 16 watches of calms and 10 with gales; the latter also came nearly all from the E. S. E. by the E. to N. N. W.; only twice from the south.

There was in June the enormous number of hours of fog, 238, two-fifths of which were accompanied almost exclusively by easterly winds, (from the near warm sea beyond the ice,) and hardly any by westerly or southwesterly winds. Under and on the coast the sky is, according to Scoresby and Sabine, generally clear, and fogs occur: mostly in calms, which is corroborated by our observations.

There was little rain in June, but the more snow; two-fifths of the aggregate number of hours of snow during the cruise, not so thick, however, as in Hinlopen Straits, and north of it, once for three days and again for two days in succession, for the most part with northerly, easterly, and southeasterly winds. The proportion of sky covered was great, 8.7; it was not for a single day entirely clear, hardly for a couple of watches on the 24th, when the company was surprised to see ships quite close-to.

In July the first attempt was made for the Spitzbergen reef, and that to the northwest of Spitzbergen, with the return to the Greenland ice. The ship, therefore, was successively on the eastern, the northern, and the western border of the ice, and then at the southwest coast of Spitzbergen, where a landing was effected.

There are many winds in July from the quarter N. N. W. to N. E., and also from S. E., but the other directions are also represented in the table more evenly; their average force is only 3. There were more calms than in June: they decrease in number with the advance of the summer. There were only 7 gales.

The number of hours of fog was considerable in July, and is the fourth part of the sum total for the cruise, or exactly the monthly average, but they were now principally with winds from the N. W. to N., and E. S. E. to W.; that is, always from the open sea. There was more rain than in June, 10 per cent. of the sum total, mostly with easterly winds; and much less snow, 7 per cent. of the sum total, nearly exclusively with winds from the N. N. W. to N. The average proportion of covered sky was 8.2; there were several watches with an entirely clear sky.

During the first half of August the ship was off Greenland, during the other half on the passage to Hinlopen Strait, and within the latter. The meteorological character of the month, therefore, varies according to the locality. Off

Notes.

215-17. Greenland the heaviest and longest gale was experienced, blowing throughout 17 watches from the N. E. to the N.; another one in Hinlopen Strait, blowing through 4 watches from E. S. E. to S. E., in the direction of the strait, in which the wind generally blows. The average force of the winds for the month is only 3.1, and, excepting the two gales, hardly 2; there were only 64 hours of fog in the month, 12 per cent. of the sum total, principally with N. W. and N. E. winds. The hours of rain were 9, not quite 6 per cent. of the sum total; hours of snow, 25, about 8 per cent. The weather was clearer, the average proportion of sky covered, only 7.2. There were a number of watches with a perfectly clear sky, off Greenland as well as in Hinlopen Strait. Off Greenland new ice had already formed.

In the first part of September the ship remained in Hinlopen Strait, and made then the last attempt toward north; in the second half she was sailing home. Winds from N. W. to N. E. were preponderating; there was a gale in the strait from the east, and another on the high sea in the latitude of the North Cape, also from the east. The average force of the wind was 3.5. There were many calms, especially in the strait; as also much fog and snow, likewise almost exclusively in the strait. At one time snow fell for three days without interruption, in flakes as large as walnuts, as observed also by Parry. There were 91 hours of fog, 17 per cent. of the sum total, and 116 hours of snow, 38 per cent. Much rain fell in addition, viz, 91 hours, or 55 per cent. of the sum total, part of which, however, in lower latitudes on the passage home. Parry complains of the same even in his higher latitudes. The average proportion of covered sky is great, 8.6; there is hardly one clear watch recorded.

216. [216] It is generally known that cold by no means depends upon the parallel of latitude, least so in the higher latitudes. The Equator is as little the warmest as the Poles are the coldest parts of the globe. Winter Island may well be considered the physical North Pole in the summer season, as the mean temperature of July is for—

Winter Island,	in latitude	66° 10′ N.,	longitude	83° 30′	W. of Greenwich,	35°.4
Port Bowen,	do.	73° 14′	do.	88° 54′	do.	36°.5
Igloolik,	do.	79° 30′	do.	80° 50′	do.	39°.0
Boothia Felix,	do.	70° 00′	do.	93° 00′	do.	41°.5
Godhaab,	do.	64° 05′	do.	52° 05′	do.	41°.9
And Melville Island,		75° 00′	do.	112° 00′	do.	42°.6

And the quarterly mean for June, July, and August, of—

Winter Island	32°.0
Port Bowen	34°.3
Igloolik	34°.9
And Melville Island	37°.2

From this cause the flora and fauna are the poorest on Winter Island.

In the winter season, however, it is coldest at the mouth of the Lena, in New Siberia. (Compare Dove.)

217. [217] All northern voyagers speak of these storm-squalls lasting only a few hours, which constitute one of the many peculiarities of the meteorology of the Northern Sea. They occur mostly in the vicinity of the ice, thus showing their origin. The journal of the expedition records them frequently on the Spitzber

gen reef as setting in from the S. E., and in the Hinlopen Straits, traveling in their direction, but also off the Greenland wall, coming there mostly from the east, and thence, perhaps, traveling into the warmer bights of the Scoresby Sound, Davy Sound, &c., which extend far west deep into Greenland, and, perhaps, run entirely through it. On the high sea, where the ship had to lay-to, the squalls from the east were the warm, those from the south the icy. The former came from the sea, the latter from the direction of Iceland over the wide fields of ice. **Note. 217.** (Con'd.)

Although it may, on account of the comparatively few observations, be considered a venture, I have attempted to establish for the Greenland Sea and for Hinlopen Straits, the two regions where the ship remained for some time, the influence of the winds on the movements of the barometer and of the thermometer, and on the kind and quantity of precipitated moisture. I have noted first the respective data for each wind, then combined the winds around each of the eight principal points of the compass according to the formula North = N. + N. by W. + N. by E. + ½ N. N. W. + ½ N. N. E., and lastly computed the daily means.

Thus I obtained:

1. For the time from the 6th to the 23d of June, off Greenland, in latitude 76° to 73° N., and longitude 12° to 16° W.:

Wind.	Pressure of air, (English inches.)	Temperature, (Fahrenheit.) °	Hours of fog.	Hours of rain.	Hours of snow.
North	29.618	32.11	17	....	45
Northeast	29.692	33.46	18	....	13
East	29.668	32.86	9	....	25
Southeast	29.632	31.38	8	2	22
South	29.820	30.46	....	....	6
Southwest	29.846	31.61	....	....	....
West	29.781	33.84	....	....	....
Northwest	29.802	32.67	2	....	12
Calms	29.942	32.90	....	....	....

2. For the time from August 20 to September 12, in Hinlopen Straits:

Wind.	Pressure of air, (English inches.)	Temperature, (Fahrenheit.) °	Hours of fog.	Hours of rain.	Hours of snow.
North	29.806	31.10	4	....	21
East	29.541	32.96	13	26	24
Southeast	29.859	30.71	13	6	7
South	29.917	31.42	2	....	....
West	29.920	33.57	4	....	....
Northwest	29.750	31.94	3	....	21
Calms	29.842	32.51	46	6	7

Off Greenland southern winds are the coldest, in Hinlopen Straits the southeastern, corresponding with the position of the ice; in both regions the west wind, coming always from the land, is the warmest. Snow and fogs occur with winds from the N. W., through N. to S. E. The frequent rain, snow, and fog, with easterly winds in Hinlopen Straits, suggests a partly open water in an easterly direction. It is possible that the frequent easterly winds of the last

Notes.

217-18. year have caused in the region of Nova Zembla a comparatively open sea, and that an attempt to penetrate north by passing to the southward of Bear Island and Gillis Land, and then proceeding between the latter and Nova Zembla, might have been more successful in that season than the attempt west of Spitzbergen.

218. [218] The following are the observations of the deviation of the compass in the Northern Sea by the expedition:

Number.	Variation.	Latitude.	Longitude.	Date.
	° ′	° ′	° ′	
1	44 46 west	73 48 north	15 42 west	June 16.
2	44 09 west	73 20 north	16 12 west	June 20.
3	42 38 west	73 17 north	16 19 west	August 6.
4	42 31 west	75 00 north	13 17 west	June 10.
5	41 25 west	73 21 north	16 05 west	August 7.
6	41 19 west	74 19 north	13 12 west	July 29.
7	40 02 west	74 48 north	13 38 west	June 26.
8	39 32 west	75 03 north	11 45 west	June 29.
9	38 42 west	75 20 north	10 08 west	July 25.
10	37 50 west	75 00 north	9 45 west	July 26.
11	37 46 west	74 42 north	11 26 west	July 26.
12	37 22 west	75 25 north	9 45 west	July 25.
13	37 10 west	74 55 north	9 48 west	July 26.
14	35 50 west	75 33 north	8 12 west	July 24.
15	32 36 west	75 50 north	4 22 west	July 23.
16	31 14 west	73 10 north	3 20 west	August 12.
17	30 41 west	73 16 north	4 02 west	June 2.
18	30 08 west	76 11 north	1 05 west	July 22.
19	30 04 west	75 08 north	4 53 west	June 30.
20	28 55 west	73 45 north	1 56 west	August 13.
21	28 28 west	76 24 north	0 20 east	July 21.
22	27 36 west	72 32 north	4 57 east	July 20.
23	27 18 west	72 32 north	2 10 west	August 11.
24	26 56 west	77 19 north	4 08 east	July 21.
25	26 53 west	64 49 north	0 47 west	May 26.
26	26 41 west	68 05 north	0 30 west	May 28.
27	26 14 west	79 07 north	5 06 east	July 20.
28	26 02 west	65 52 north	1 33 west	May 27.
29	25 19 west	69 30 north	1 22 east	September 23.
30	24 59 west	63 31 north	0 30 east	May 25.
31	24 27 west	70 44 north	2 23 west	June 1.
32	23 33 west	71 40 north	3 16 east	September 23.
33	22 02 west	62 44 north	0 12 east	May 5.
34	21 16 west	75 13 north	4 30 east	July 1.
35	19 55 west	79 24 north	10 22 east	August 17.
36	18 32 west	78 52 north	9 47 east	August 16.
37	17 59 west	77 21 north	14 05 east	July 12.
38	17 52 west	77 25 north	14 05 east	July 12.
39	17 12 west	78 05 north	11 17 east	July 16.
40	17 02 west	80 40 north	15 57 east	September 13.
41	16 09 west	80 52 north	15 19 east	September 14.
42	15 21 west	77 38 north	14 15 east	July 15.
43	15 14 west	77 56 north	12 13 east	July 15.
44	14 45 west	80 00 north	13 43 east	August 17.
45	13 54 west	75 14 north	17 35 east	July 8.
46	13 36 west	80 04 north	17 20 east	August 18.
47	11 13 west	75 52 north	18 42 east	July 7.
48	10 26 west	79 03 north	21 02 east	September 2.
49	9 12 west	79 20 north	21 41 east	August 30.
50	8 25 west	79 20 north	21 27 east	August 22.

As the most reliable of all these observations, No. 5, obtained August 7 on the ice off the Greenland coast, is noted. No. 25 and No. 48 are also said to be very good, the latter being the mean of a number of observations made on shore in Hinlopen Straits. Others, on the contrary, which were obtained on board in a high sea, as, for instance, Nos. 6, 7, 19, 29, 32, 34, are uncertain. Note. 218. (Con'd.)

It was hardly possible to combine even the best of these observations with the isogonic curves of General Sabine, after allowing for the latter an annual decrease of seven minutes, as these reach only to the Arctic circle and an interpolation across the entire Northern Sea from the Greenland coast to Hinlopen Straits would have been required. I have, therefore, treated the observations of the Greenland independently, and have attempted to deduce from them the probable values for all the meridians through which the ship has sailed; the comparison of the new curves thus obtained with the previous, reduced to the epoch of 1868, proves them in the whole satisfactory, and, when corrected from the observations of the expedition of 1869, they will be quite reliable.

It was found necessary to divide the observations into eight groups, according to the localities and the time.

Group A consists of Nos. 1, 2, 3, 4, 5, 6, 7, and 8.

Group B consists of Nos. 9, 10, 11, 12, 13, and 14.

Group C consists of Nos. 15, 18, 19, 21, 22, 24, 27, and 34.

Group D consists of Nos. 16, 20, and 23.

Group E consists of Nos. 17, 25, 26, 28, 29, 30, 31, 32, and 33.

Group F consists of Nos. 37, 38, 39, 42, 43, 45, and 47.

Group G consists of Nos. 35, 36, 44, and 46.

Group H consists of Nos. 40, 41, 48, 49, and 50.

Within each group a mean value was determined for a middle latitude and longitude, (the center of the group,) in which a higher valuation was placed upon the observations nearest to the latter, as also upon those which were considered the best, while the more doubtful were less regarded; and by interpolating between these centers the declinations were obtained for the intervening meridians and parallels of latitudes. Thus the system of isogonic curves was arrived at.

E.

REFERENCES AND NOTES TO DR. A. MÜHRY'S PAPER.

Notes.

219-21. [219] This will be disputed by physicists, who cling to a few contradictory experiments; nature, however, offers more correct and decisive data which are confirmed undisputably by the result of our inquiries into the vertical distribution of the oceanic currents.

THE AUTHOR.

[Compare, also, the foot-note on page 125.—HYDROGRAPHIC OFFICE.]

220. [220] It can, for instance, be assumed (water being heaviest at 39°.2) that water of a temperature of 32° is about as heavy as water of a temperature of 46°.6, and that consequently water of 32°, and more so of 34°, as it is generally found on the surface of the sea, even between floating ice, is heavier than the warm water of 48°, which may push against it from the south; then the former (the northern) must submerge beneath this warmer water, and proceed thence as a sub-surface current, while the latter is deflected laterally, and must also receive and carry with it the ice and the drift-wood which may have been drifting on the northern stream. But water of a temperature of 38°.8, coming from the south, is heavier than water of 34°, or 32°, or 28°, which is either at rest, or flows from the north against the former; then the colder water will be the less heavy, and must remain on the surface, while the warmer water from the south must dive beneath it.

This is in conformity with the theory, and we will find that it is not in conflict with experience.

Sea-water in the Polar basin remains fluid to a temperature of 28°, and the inflowing Gulf Stream has a temperature which surely cannot at Newfoundland (latitude 45°) be placed lower than 54°.5. Between these two extreme figures, therefore, fluctuate the temperature-relations of the waters which mix with each other in the aperture of the basin; the inflowing Gulf Stream becomes heavier the more it cools down to 38°.8, and the outgoing Polar stream the nearer its temperature rises to the same figure. (Information in regard to the distribution of the temperature on the surface of the Atlantic Ocean to 55° N., 10° W., will be found in the "Onderzoekingen met den Zeethermometer," edited by the Royal Netherland Meteorological Institute at Utrecht, 1861.)

221. [221] This vertically reversed order of the temperature in the Polar basin, viz, the increase downward, is established to a certainty by the best authorities; but as the temperature has, by some other good authorities, been found, on the contrary, decreasing downward, a short explanation will be in place. The observations of the deep-sea temperature are more easily subject to deception in the summer than in the winter, on account of the melted waters of glaciers, field-ice, and snow, then swimming like oil on the cold surface as less heavy,

Notes.

because without salt, or containing but little, although, perhaps, of a tempera- ture of 38°.8, and this is not the natural status. It is, therefore, advisable to observe in winter, and to take into consideration also the specific gravity. The following later observations in the winter, and in the summer by McClintock and Walker, in Baffin's Bay, answer these requirements, and give also satisfactory evidence for the correctness of the laws deduced. No other observations obtained in the winter are known to the author. (Compare Fitz Roy, Meteorological Papers No. 4, for 1860.) 221-22.

In March, 1857, in latitude 69° N., longitude 59° W.:

Depth.	Temperature.	Specific gravity.
	°	
Surface	29.1	1028
Thirty feet	30.0	1028
Seven hundred and twenty feet	34.4	1028

In August, 1857, in latitude 75° N., longitude 59° W.:

Depth.	Temperature.	Specific gravity.
	°	
Surface	37.8	1023
One hundred and fifty feet	31.6	1024
Three hundred feet	30.7	1025
Six hundred and eighty-four feet	30.0	1028

In the summer (July, 1827) Parry also found north of Spitzbergen, in latitude 82° N., longitude 20° E.:

Depth.	Temperature.	Specific gravity.
	°	
Surface	32.4	1000
Two thousand four hundred feet	31.1	1028

[222] More than these short indications will be found in the appendix to the Klimatographische Uebersicht der Erde, 1862, p. 708: "Versuch, ein System der grossen Meeresströmungen aufzustellen." 222.

The reader may question the centrifugal power of the earth as the motor of the longitudinal oceanic circulation; this is, however, the only satisfactory explanation of these phenomena, and it does not lack some very good theoretical authorities, viz, Kepler, Varenius, and Fourier. The explanation most frequently adopted is, to ascribe the cause of them to the trade-winds; but against this there is the fact that the current at places has a depth of some thousand feet.

As there are but very few investigations in that respect, attention is drawn to the reliable observations of Irminger, who by Aimé's submarine current-vane found on March 17th, in latitude 25° N., longitude 65° W., at a depth of 2,934 feet a current to the N. W. (Compare Zeitschrift für Allg. Erdk., 1854, p. 169.)

Notes.

223-29. [223] Compare S. Clavering, Journal of a voyage to the east coast of Greenland. Edinburgh. New Philosophical Journal, July, 1830.

224. [224] Captain Graah, of the Danish navy, who remained on the east coast of Southern Greenland, between latitudes 60° and 65½° N., for two summers and one winter, (1829,) found the temperature of the "Arctic stream" never higher than 34°, (ranging between 28° and 34°;) but in the entrance of Davis' Straits, in close vicinity to ice, he observed 39° and 41°, although he had found nowhere else in the vicinity of ice above 36°. He concludes therefrom that a southern stream must enter there. (Reyse til Ostkysten af Grönland; Kjöb., 1832.)

[For an account of Graah's expedition see note 107.—Hydrographic Office.]

225. [225] There are navigators who ascribe the well known great southern drift of ice along the western side of Baffin's Bay to the prevalence of northwesterly winds. That these winds prevail there is sure, but the drift keeps so close to the coast that they cannot be the sole cause of it.

226. [226] This branch of the Gulf Stream may be considered a new discovery, as Rennell (compare "an investigation of the currents of the Atlantic, 1832") would not believe in it, and, being at the time generally accepted as the authority for Atlantic currents, thus prevented inquiries into it.

227. [227] An unequal diffusion of the salt in the great ocean (except at the surface of it, where it is caused in the summer by melted ice and snow remaining uppermost on account of their lesser weight) we cannot adopt, at least not so great, so extended, and so permanent an inequality, that it could be accepted as the cause of the existing circulation.

228. [228] The accurate observations from the middle of July to the middle of August were as follows:

	Sea.	Air.
	°	°
Latitude 77° to 79° N	36.7	37.4
Latitude 74° to 77° N	38.8	37.0
Latitude 70° to 74° N	41.5	42.6
Parry found latitude 73°, longitude 8° W	also 39.0	....

The temperature of the same current and at the same time, at the Faroe Islands, is, according to Irminger, 50°.0. Other temperature observations will be found on the Polar chart in P. Sutherland's journal of a voyage in Baffin's Bay, 1852, vol. 1.

229. [229] The depth of the icebergs below the surface of the sea, generally assumed to be $\frac{6}{8}$ of the entire iceberg, is probably not so great, as they consist of glacier-

ice, the result of the compression of snow, and therefore porous, still containing air and of less weight than field-ice. 229-32,

[230] Malmgrén, the Swedish Expedition to Spitzbergen, 1861, in the Geographische Mittheilungen for 1863, p. 402. 230.

In regard to the climate of Spitzbergen I will say but a few words. Spitzbergen is crossed, according to Dove, by the annual isotherms 14° and 18°.5, by the former in the north, by the latter in the south. The highest temperature observed by the expedition on shore was 60°.8, on the 15th of July, at Wide Bay; at the same time Dr. von Goes observed on board the Magdalena, lying at anchor in the northern part of the bay, 82°.4 in the sun, and 53°.6 in the shade.

The causes of this surprisingly mild climate in such a high latitude are the insular situation and the Gulf Stream, which is proved to wash the entire western coast and, at least in certain seasons, in August and September, also some parts of the northern coast. Toward the end of May, or in the beginning of June, the slopes of the high mountains, and partly also the coast, become free of snow which, however, remains in the valleys until late in the summer, at least on the northern coast. Toward the end of April the southwest coast can be approached by vessels, and in June the bays of the same throw off their bridges of ice, while on the west coast of the Northeast Land the ice is still firm in the fiords at the end of July and the beginning of August. There is hardly any precipitation of moisture in summer, and thunder has never been heard.

[231] Scoresby, who after seventeen whaling cruises in that part of the Arctic Ocean knew it better than any one else, but believing that ice could also form in the open sea at very great distances from land, had the idea that the sea which he assumed to exist around the North Pole was covered with a coat of ice, and that the Pole could only be reached in a sleigh. He did not know yet the belt-like form of the packed ice, which we first learned from Parry after his remarkable voyage, in 1827, on foot over the ice to latitude 82° 44′ N., (and which formation is even now not yet generally quite well understood.) Scoresby penetrated through that belt, but failed to reach the Pole, not on account of impenetrable ice, but for the want of ice, because after crossing the pack-ice he reached the open sea, but then had no ship. 231.

[232] The arguments for an open sea at the North Pole, and a consequent milder temperature there, will not be repeated here; one only less known may be stated. There are in Northern Siberia, on the river Lena, in the district of Schigansk, latitude 65° to 73° N., among the birds of passage, which seek in the beginning of the winter a warmer climate, some going north across the sea. This would indicate the existence of islands there. (Geographische Mittheilungen, 1857.) 232.

VI.

SECOND APPENDIX.

47

SECOND APPENDIX.

I.—THE GULF STREAM EAST OF THE NORTH CAPE.

BY A. VON MIDDENDORF,

HONORARY MEMBER OF THE ACADEMY OF SCIENCES OF ST. PETERSBURG.

[The cruise of the Russian Corvette Warjäg in the Northern Sea, in 1870, has been preliminarily noticed on page 192 of this volume. Mr. von Middendorf, who accompanied His Imperial Highness the Grand Duke Alexei on this cruise, has since published in the January number of the Geographische Mittheilungen for 1871, the following summary, embracing the results of the careful observations of the temperature of sea and air made on board of the Warjäg, two hourly, and at times even in shorter intervals, in a region, thus far, partly unexplored in this respect.—HYDROGRAPHIC OFFICE.]

*   *   *   *   *   *   *

Before entering upon the discussion of the observations made on board of the Warjäg, I beg permission to record again an isolated observation of the temperature east of the North Cape, which appears to have escaped the eye of Dr. Petermann, and to add a few statements from Russian publications of older date.

Just thirty years ago I observed, east of the Fisher (Rybatschij) Peninsula of Russian Lapland, in latitude 70° N., and on the meridian of the east coast of the Ladoga Sea, at the end of August, a temperature of 48°.2, and ascertained that the sea, in the vicinity of the Kola Bay, remains open throughout the winter, it being then the resort of numerous flocks of sea-fowl, and that, therefore, it must have a higher temperature than waters in lower latitudes. (Compare my "Sibirische Reise, 1851, Wirbellose Thiere," ii, 1, p. 382, note 3.) This is confirmed by the well established fact (recorded by Oseretzkowski, Description of Kola and Astrachan, 1804; and by Reinike, Description of Kola City, 1830) that the Kola Bay itself which, although but narrow, has a length of 37 miles, freezes only in the most severe winters, never before January and February, and only to Saljnyi Island, 17 miles from its head; a fact the more remarkable as the rivers Kola and Tuloma empty into it a great quantity of icy mountain-water.

The same careful observer, Admiral Reinike, states that the winter in Kola is not any more severe than in Archangel. The rivers in that vicinity, in fact, throw off their ice about the 13th of May, while the Dwina at Archangel, 4½° farther southward, is recorded to do so generally on the 14th of the same month. (Lütke, four voyages to the Northern Sea, 1828, i, p. 132; and calendar for 1869 by the Imperial Academy of Sciences, p. 168, Russian edition.)

The results of the observations of the Warjäg will be stated in following the course of the Gulf Stream from the west to the eastward.

1. *In the direction from South Iceland to Tromsö, as well as in that from South Iceland to the south point of Norway, between the Shetland and the Orkney Islands,*

and also parallel to the west coast of Norway, the surface of the sea has been found by the Warjäg of a temperature of from 2° to 4½° higher than might have been expected from Dr. Petermann's July curves on chart No. 1. It therefore appears that in the summer of 1870 the Gulf Stream was running less mixed with other waters, and more decidedly toward the north than is generally the case, and also that Dr. Petermann's July isothermal curve of 10° R. should probably be drawn higher north.

The highest surface-temperature observed by us was 10° R., (54°.5 F.,) viz:

a) On the high sea, nearly in sight of the islands off Tromsö, in latitude 69⅔° N.

b) In the roads of Reikiavik, in latitude 64° N.

c) On the meridian of the center of Iceland, in latitude 61¼° N.*

We should consider this higher temperature unhesitatingly as a confirmation of Petermann's July curves, the more so as it is known that there is generally a delay of the extreme monthly temperatures, and as we were in that vicinity in the warmest season during the month of August. We were, however, off Tromsö in the beginning of that month, and Lord Dufferin observed, also 54° in 1865, near Tromsö, but as early as on the 19th of July, and a degree higher than ourselves.

These observations agree with those of the Warjäg on her passage from Petersburg to Archangel, viz, 54°.5 as early as the middle of July, in the Bay of Kiel, and 53°.4 to 55°.6 on the coast of Norway, north of latitude 60°, on the 17th of June.

Such extraordinarily high temperatures must especially be borne in mind in referring to the Gulf Stream the temperatures observed by us as early as in the middle of July, far to the east of this, of which we shall speak hereafter. We nevertheless found the penetration of the Polar Stream into the Gulf Stream even more decided than shown by Dr. Petermann on his July chart, the minimum of 42°.1 having been observed by the Warjäg down to latitude 64½° N.

The North Atlantic Ocean being there furrowed by warm and cold bands, as demonstrated by Admiral Irminger, it matters less to show these differences than to prove that the Gulf Stream carries in the summer a temperature of 54°.5 until it meets the North Cape stream. Our observations confirm that this latter stream of warm water reaches down to very considerable depths, as in latitude 69½° N., on the meridian of the southernmost point of the Scandinavian Peninsula, at a surface temperature of 50°.7, we found at 40 fathoms depth still 46°.4, and at 80 fathoms 45°.5.

That so high temperatures were observed along the coast of Norway thus early is important, and I infer from the meteorological journal of the Warjäg, that the higher of the above two figures (55°.6) expresses the temperature of the high sea, while the lower (53°.4) is that of the currents in the vicinity of the coast. In the higher latitudes, but near the chain of islands off the coast, (the Lofotes,) the temperature varied in alternate bands, and even fell as low as 47°.7 and 47°.

The further course of the vessel showed plainly that not the higher latitude, but these islands which bar the Gulf Stream and the influx of cold water from the melting snow and the glaciers, causes the decrease of the temperature, while

* The same temperature was observed also in latitude 59½° N., west of the meridian of the Hebrides, and up to the strait between the Shetland and the Orkney Islands, but these observations agree with the July-curve of Dr. Petermann.

to the west, on the high sea, the higher temperature of the water extends much farther north. As soon as the corvette, after passing Hammerfest, entered into a higher latitude and more open water, the temperature again rose on June 27, from 47°.7 to 48°.9, and even to 50°.

This latter temperature was observed in the North Cape stream in the end of June, in latitude 71° 10′ (the highest in which the ship doubled the North-Kyn) as also west and east of the North-Kyn up to the meridian of the Sylte Fiord or Sylte-vik, west of Wardö. I have to state expressly, however, that the course of the ship was near the coast, and I have no doubt that farther north, in the open sea, 54.°5 would have been observed on this meridian, a few weeks later. I say so with confidence, although we ourselves, on going homeward over the same route, but still closer to the coast, observed throughout only 47°.7, and in sight of the North-Kyn only 47°.1.

From the above I conclude:

2. *That the July isothermal curve of 10° R. (54°.5 F.) for 1870 must not be drawn through the interior of Norway, but, on the contrary, outside of the Lofotes, at some distance from the north coast of Scandinavia; and that it does not run parallel to the isothermal curve of 8° R., but is crossed by an offset of the latter toward the coast.*

3. *The North Cape stream, cooled down hardly perceptibly, runs past the White Sea toward the entrance of the Kara Sea, so that in the vicinity of Kolgujev Island there are still bands which in July have a temperature of nearly 54°.5. The July curves of 6° and 4° R., (45°.5 and 41° F.,) therefore, have to be replaced by those of 10° to 7° R., (54°.5 to 47°.8 F.)*

*On the meridian of the Kanin Peninsula the North Cape stream, which there we shall call the Kanin stream, has, at a width of more than 2 degrees of latitude, still a very considerable depth, at which it does not cool down below 47°.7. If, however, we should consider the temperatures of 38°.7 to 41°, observed by Dr. Bessels on his return from Nova Zembla in latitude 74° N., as the edge of the Gulf Stream, the Kanin stream would have a width of more than 4 degrees of latitude.**

The Kanin stream has a depth of about 20 to 30 fathoms; its temperature, however, decreases downward the more rapidly the higher it is on the surface, evidently because the temperature at about 30 fathoms is on the average throughout about 38°.7 to 42°.0. Only north of the parallel of latitude 70° we found at the bottom (in 40 fathoms) Polar water of less than 36°.5 down to 33°.8.

In going from Archangel to Nova Zembla the Warjäg suddenly observed, in the mouth of the White Sea, the high temperatures of the Gulf Stream. We found in latitude 68° N., on the central line of the mouth, 43°.3, and to the east of it, nearer to the Kanin promontory, in latitude 68° 40′ N., 49.°3. The farther northeast we steered, the more the temperature of the surface of the sea increased, until in latitude 69° N., on the meridian of the center of the Kanin Peninsula, (44° 20′ E.,) we crossed the maximum temperature of 53°.4. Thence we proceeded westward to latitude 69° 45′ N., longitude 49° E., (the meridian of the west coast of Kolgujev Island,) observing still between 51°.1 and 49°.3. We then came to a second narrower band of warmer water showing 52°.7, which to the northeast soon cooled down to 50°, and in 70° 40′ N., 50° 30′ E., (to the east of the meridian of the east coast of Kolgujev Island,) to 47°.8.

---

*We draw attention to Reinike's statement, (p. 34 of his book,) that he never heard that summer Polar ice had been seen in a lower latitude than 72½°. The Kanin stream evidently prevents it going more southward.

Farther toward Nova Zembla the temperature fell rapidly, as we will show more in detail presently.

That the Kanin stream extends here over more than 2 degrees of latitude, we ascertained on our return passage from Nova Zembla to the coast of Russian Lapland and Wardö. In this summer the Warjäg reached her highest latitude in 71° 14′ N. on the meridian of the west coast of Kolgujev Island, (48° E.,) and the temperature of the surface of the sea was found there to be as high as 45°.5.

Turning southward again, 47°.7 were observed in latitude 71° N., on the meridian of the east coast of the Kanin Peninsula, then 48°.8, and so on increasing until 55°, the highest temperature observed by the Warjäg in the open sea east of North Cape, was obtained on the 31st of July in latitude 69° N., hardly 25 miles from the Lapland coast, nearly in sight, but a little to the east of the Seven Islands, (Ssemj Ostrowov.) There we had evidently entered the same band which two weeks before, near the opposite eastern shore of the entrance to the White Sea, had shown 53°.4. Higher temperatures of the sea were observed on the Warjäg only under the influence of insolation, and in shallow water in the proximity of the main.*

If we inquire where this warm water of so great a volume goes to, it appears to me, without doubt, that it branches at Nova Zembla, and we have good reason to assume that the main branch proceeds toward the Kara Sea, especially to the Petschora region and Waigat's Strait, (Jugorskij Shar,) and a side branch north along the west coast of Nova Zembla.

4. *A northerly current along the northwest coast of Nova Zembla is unmistakable; it is probably one of the continuations of the Kanin stream.*

In following carefully Admiral Lütke's examinations of the Nova Zembla Sea during four summers,† the steadiness and great strength of this current cannot escape us; we find it, close to the coast, in latitude 76° N., still powerful enough to extend to 76½° N., where it meets waters of little or no motion which reach to Cape Nassau.

Barents, while wintering on the north coast of Nova Zembla, observed the sea to be open in each of the winter months, and sometimes entirely free of ice; in the beginning of May the ice disappeared entirely. Furthermore, at the northernmost of the three meteorological stations on Nova Zembla, (Shallow Bay in nearly 74° N.,) the mean temperature of the air has been found higher than at the two more southern stations.

The current appears to have the same direction even as low as latitude 71° and 70° N., as the Warjäg made Meshduscharskij Island, (off Kostin Shar,) when, by dead reckoning, she was thought to be considerably south of it.

5. *These extensions of the Gulf Stream are proved, additionally, by drift produce.*

I not only saw a bean of the Brazilian *Entada gigalobium*, which had been found on the coast of Nova Zembla, but there were also among the products of the province Archangel, which were exhibited by the Governor to His Imperial Highness the Grand Duke, two thick pieces of bamboo cane, which also came from Nova Zembla. There was, furthermore, years ago presented to the Impe-

* Thus in latitude 64° 40′ N., outside of the Dwina Bar, on the 24th of June, and some day previous, with northerly wind up to 66°.9; in latitude 65° N., at the Solowetski Islands, 62°.2; in Catharine Harbor, Kola Bay, latitude 69° N., 58°.3; at Wadsö, latitude 70° N., 59°.0.

† Lütke (Viermalige Reise, 1828, vol. ii, p. 61, 64, 80, and 191) records a current of 58 nautical miles in 24 hours. Captain Johannesen found the same.

rial Russian Geographical Society one of the glass-balls which are used by the fishermen of the Lofotes for buoys.

6. *While the Kanin stream bounds against the Kanin promontory, a branch appears to part from it, which can be traced along the east coast of the White Sea and through the throat of the White Sea to the mouth of the Dwina, and beyond it toward the west.*

I trace this side branch first in the eastern half of the entrance to the throat of the White Sea in latitude 68° 40′ N., where we observed a temperature of 49°.3, north of the extreme tongue of the Kanin promontory.

The continuation of it we find from the meteorological journal of the Warjäg on the passage to Archangel. Between the neck of the White Sea and its blind bag, near the west coast of the latter, (south of the coast of Ssossnowetz,) in latitude 66° 24′ N., only 39°.9 were observed on the 22d of June. From there the corvette was steered to the eastern coast (Simnij Bereg) toward Cape Intzy, and found suddenly, only five hours later, in latitude 66° N., a temperature of the water of 63°, a difference of 23°. This high temperature of the water continued to the mouth of the Dwina, and I can only account for such in this early season by the meeting of the Kanin stream, which itself has a temperature of 50°, with the water of the Dwina heated in the interior in more southern latitudes, to which the shoalness of the water and insolation may contribute. My supposition is supported by the fact that in the end of June the temperature of the sea on the Dwina Bar rose to 66°.9, only with fresh northerly winds, and fell to 54°.5 immediately when the wind died away.*

A further confirmation is the fact that at Cape Semljanoj, on the east side of the White Sea, the coast, bending toward the north and not south, begins to be less sterile; we find there again trees, and a luxuriant growth of grass which reaches close to the shore; cows give splendid milk, and not only vegetables are raised, but even some barley. This doubtless is due to the warm water of the Gulf Stream, which also invites the inhabitants of the coast to congregate at Cape Intzy as early as February for the capture of the seal and their young brood.

7. *The Gulf Stream does not bound directly against the west coast of Nova Zembla; a belt of cold water, (we observed 45.°7 to 41.°5,†) at places 60 miles broad, intervenes between it and the shore, girding at least the southern half of Nova Zembla.*

The White Sea, as well as the Arctic, in the direction from Kanin to Nova Zembla, have, on the average, a depth of but 40 to 60 fathoms; only in the central part of the White Sea, within very narrow limits, were 150 fathoms measured. The few soundings which were obtained in the above-named belt of cold water indicate that it has probably a depth thrice as great.

---

* With great satisfaction I find in the Sprawotschnaja Kniga of the government of Archangel for 1850, p. 178, ample confirmation that this generally takes place, and the above cannot be considered an exception. It is stated there that at Ssjusjma, a village resorted to for bathing, on the road from Archangel to Onega, 85 verst from the former, the sea grows warmer with N. E., N., and N. W. winds, although these are sometimes quite chilly, the temperature rising even to 70°, while with S. E., S., and S. W. winds, which sometimes are very warm, the temperature of the water decreases, falling even to 41°. Another statement in the Archangelskij Sbornik for 1863, p. 58, also supports my argument. It must, it is stated there, appear strange that Dwina Bay, notwithstanding the N. E. winds prevailing in the spring, is earlier free of ice than the Kandalakscha and Onega Bays.

† Baer observed in Matotschkin Shar, (Matthew Strait,) between the 3d and the 16th of August, 40°.8.

I conjecture that an easterly Polar coast-current runs in that furrow, connected with the waters discharging through the Kara Strait, (Lütke Viermalige Reise, ii, p. 72 and 78,) and through Matthew Strait which is always full of ice. But this colder water (45°.5 to 40°, corresponding nicely with the maximum 43°.5, observed by the Swedish expedition on the coast of Spitzbergen) has surely a not inconsiderable admixture of warmer water, as the mean temperature of the air at the warmest station in Nova Zembla is in the summer only 39°.2.

On the western edge of this furrow, where the depth changes from 40 to 60 fathoms, we observed at 40 fathoms depth 33°.8, and off Kostin Shar also, at 40 fathoms, 37°.4, the surface temperature being 46°.0.

As the sea on the west coast of Norway descends to a similar furrow, I cannot help believing that these phenomena arise from general geological causes. Should not a colder coast current wash also the shores of Norway?*

8. *Corresponding to the warm stream on the east coast of the White Sea, there flows along its west coast a cold stream, the temperature of which we may consider as the local temperature corresponding to the region. It appears to continue from the entrance to the White Sea westward along the coast of Lapland.*

After, as above stated, we had observed 66°.9 on the bar of Archangel, we again found at our anchorage off the Solowetsk cloister 62°. On the passage to the Solowetsk Islands, east of them, at the entrance to the Onega Bay, (latitude 65° N.,) the thermometer went down to 48°.9.

From these islands we shaped a northeasterly course to the Lapland coast. The thermometer fell rapidly. When, on the 21st of July, in latitude 66° N. we sighted the western coast, (Terskij Bereg,) it showed 43°.2 near the same place where four weeks earlier the Warjäg had observed 39°.9. The coast continued to be covered by drift-moss, the air remained rough, and the temperature of the surface of the sea at 41°, but not less. This continued so up to latitude 67¾° N., longitude 41⅓° E., that is, to the western third of the throat of the White Sea.

From the fact that the mean temperature of the air for the year at Archangel is 33°.6, for the winter 10°.2, and for the spring 31°.3, and further that the Dwina does not throw off the ice before the middle of May, we will consider a temperature of the sea in July of 39°.9 to 43°.3, three degrees north of Archangel, rather higher, and certainly not lower, as we might have expected, and we are inclined to accept it as the local temperature, not much affected by other influences.

Reversing our course, and going from the western coast toward the Kanin promontory on the east side, the thermometer soon rose; in the center of the throat, in latitude 68°, we found 43°.2, and closer to the east coast 49°.3. The temperature of the sea changed from the local to that of the Gulf Stream.

Had we, on going north, kept on the Lapland Coast, we should doubtless have remained in cold water far beyond Swätoi-Nos. I infer this from the meteorological journal of the Warjäg on her passage to Archangel, as in 68° 24′ N. northwest of Swätoi-Nos the thermometer fell rapidly to 42°.6, and farther south, as stated previously, to the minimum 39°.9.

* For evidence that this furrow girds the southern coast of Nova Zembla, and that, on the contrary, the waters of the Bolschesemelski Samoide coast are shoal, I refer to Lütke's statements in his "Viermalige Reise," ii, p. 94.

When the Warjäg, on her return from Nova Zembla, again crossed the meridian of Swätoi Cape, she found there a temperature of 51°.1, instead of 43° or 45°, not only because this was four weeks later in the season, (31st of July,) but also because it occurred 1½° more to the northward, in the Gulf stream, instead of near the coast.

This cold stream occupies that part of the ocean bed in its entire depth, and there is no under-current at the bottom, (in 20 to 35 fathoms depth;) on the contrary, the temperature of the bottom-water is lower by 2½° than that of the surface.

9. *Relations, analogous to those just shown as existing in the White Sea, appear to exist also in the Waranger Fiord, which in fact is but a diminutive repetition of the former.*

The temperature observations of the Warjäg, on her passage to Archangel, exhibit a sudden decrease to 43°.2, and even to 42°.6, as soon as the ship on her course from North Kyn reached Wardö, while 45°.5 were recorded near the Fisher (Rybatschij) Peninsula, and farther east up to midways between the Seven Islands (Ssemj Ostrovow) and Swätoi (Holy) Cape. The difference is but small, but it was again observed when crossing the same waters six weeks later. as 50° to 54°.5 were observed everywhere in the Waranger Fiord, but only 47°8, on approaching Wardö, and this lower temperature of the sea (47° to not more than 49°) continued west until in sight of the coast to Hammerfest, and even to Tromsö.

Thus there is also in the Waranger Fiord warmer water (affected by the Gulf Stream) flowing in the eastern half, while along the western shore of its mouth, and to the west of it, along the entire coast of Norway, colder water is met. The middle band of the warm North Cape stream appears northward to draw off from Wardö, and from the Fisher Peninsula.

10. *The Gulf Stream can still be detected at Kolgujev, not only by the temperature, but also the blue color and the high salinity of the sea.*

We sailed there through water of a color of so deep a violet-blue that I was confident of finding it swarming with microscropic animalculæ and plants. My astonishment was great when I could not detect anything under the microscope. I shall again examine the residuum of the specimens.

This same water, on examination by Professor C. Schmidt in his laboratory at Dorpat, proved to be of a specific gravity of 1.02518 at 20°.4 Celsius, and consequently of a salinity of 3.4238 per centum.

We possess through Reinike (Geographische Beschreibung der Nordküste Russlands, 1850, i, 20, and Archangelskji Sbornik, i, 1863, pp. 25, 30) quite a number of determinations of the salinity of the White Sea and the Arctic Ocean along the Lapland Coast, of which the following are the principal ones:

	Specific gravity at 32° F.
On the bar of the Dwina	1.017
At Simnija Gory, (ebb)	1.018
At Simnija Gory, (flood)	1.021
At the blind head of the Onega Bay	1.021
At the Solowetsk Islands	1.023
At the entrance of the Kandalakscha Bay	1.023
At Ssosnowetz	1.024

	Specific gravity at 32° F.
At Cape Orlov, (flood)	1.025 to 1.026
At Swätoi (Holy) Cape	1.026
Near Kola Bay	1.027
Near Wardö	1.028

The water on the Dwina Bar, therefore, has a salinity of 2½ per centum, which decreases very regularly toward the mouth of the White Sea. The waters on the Lapland coast increase their salinity from east to west, reaching the maximum of 3¾ per centum at Wardö.

A salinity in the Arctic Ocean of 3½ per centum, which we find the Kanin stream to possess, is, indeed, great enough to suggest the influence of the Gulf Stream. No agreement, however, has been found with the great differences in the temperature of the water, and there remains, in this respect, an open field for further inquiry.

But from the facts ascertained thus far the important conclusion may be drawn in the interest of national economy, that the salt works at present on the shore of the Onega Bay were not located properly, and that they should be removed within the reach of the above shown branch of the Kanin Stream, either to the coast west of Swätoi-Nos, or to the south coast of the Waranger Fiord, or to the northern half of the east coast of the White Sea. These are, moreover, localities where also the required wood may easily be obtained.

There can surely be no doubt that the great number of animals of lower orders which are found near the Lapland coast, and of which lately so many specimens were procured by Mr. Jarschinski for the St. Petersburg Society of Natural History, as well as the abundance of fish, especially of herring, codfish, &c., feeding upon them, and which again are the prey of the numerous sharks and seal, are incident to the meeting of branches of the Gulf Stream with northern waters. Direct proof of this connection, however, must be left to further research.

The remarkable agreement of the temperature of air and water, and the manifest dependence of the temperature of the air from that of the water, testify to the correctness of Dr. Petermann's expression, "direct heating by warm water," (Unmittelbare Warmwasser-Heitzung.)

We would have been able to determine by the air, without ascertaining the temperature of the water, whether we were or were not within the warm water of the Gulf Stream branch. The direction of the wind had evidently but a subordinate influence on the temperature of the air.

The air was roughest (at night down to 43°.3) on the dreary west coast of the neck of the White Sea, (Terskij Bereg,) where the cold stream shows its depressing influence on the vegetation, which there is far behind that on the shores of the more northern Kandalakscha Bay. Over the warmest parts of the Gulf Stream, on the contrary, the air was never less than 54°.5,* although the thermometer generally gave higher readings on account of the insolation incident to the shallow water, or the reflection from the rocky coast when near it. For instance, when lifting the anchor off Solowetsk, 64°.4 were observed, and in Catharine Harbor, Kola Bay, (latitude 69⅓° N. on the 1st of August,) even 68°, and at midnight above 59°.

* On the highest parallel of latitude which we reached (71° 14′ N.) the temperature of the air was at noon 50°, at midnight 45°.5.

The most fluctuating temperature proved to be at our anchorage in Kostin Schar, Nova Zembla, in latitude 71° N. We find there recorded in the journal of the ship, on the 24th of July, as high as 54°.0, on the next day not more than 46°.2, and in the night succeeding as little as 38°·8.

During an excursion into the island, however, on the same 24th of July, the thermometer showed, even at midnight, in the shade more than 63°.5, and on the following day we had an oppressingly sultry air, with thunder and a short shower of rain.

Wading, on account of the steep declivities of the land, knee-deep in the bed of a considerable mountain-rivulet, I was surprised by the warmth of its swift water, which in this high latitude (71°) I had expected to find quite cold. I could hardly believe my eyes when the thermometer showed it to be, near the mouth, 57°; higher inland where it was joined by waters from lakes, 54°.5, and even close to the drift-snow which had accumulated under its bluff banks, and from which it was copiously fed, 50°. It will be found natural that I suspected warm springs in the vicinity, but instead of them I found the water in all the many shallow lakes of the same temperature.

Near one of these lakes, and evidently fed by it, was, exceptionally, a cold spring, (of 39°,) the waters of the lake oozing through a stratum of decayed clay, four feet in thickness, well covered by a growth of grass. There can, consequently, be no doubt that the high temperature of the rivulet was exclusively due to insolation, which had attained such power through the dark color of the slate precipices bordering the water.

It is this important agency, contributing to the higher temperature of the ocean, to which I intended to draw attention: insolation, acting directly in the immediate vicinity of the coast as well as in the shallow parts of the ocean, and indirectly through the great sweet-water tributaries which, even in the highest latitudes, carry vast stores of heat, thus collected on the land, into the sea. It should be well considered, the more as the daily fluctuation of the temperature of the sea is so slight, frequently even quite imperceptible.

In Catharine Harbor, Kola Bay, in latitude 69⅓° N., where the sea can enter only at flood-tide, the surface-temperature remained at 54°.5 to 58°, while at a depth of 10 fathoms 51° was observed; at 40 fathoms, 50°; and at 75 fathoms, still 47°.3. The insolation was there, as already stated, remarkably strong, the temperature of the air rising, on the 1st of August, at 4 hours p. m., to 68°.9.

I state expressly that when speaking of currents I did not intend to refer to the flowing of the water in a certain direction; the term "current" expresses, in this discussion, exclusively the result of temperature observations. It is, however, a matter of course that, when discovering the sea at Kolgujev to possess an equatorial temperature, we must presume that the water has flown there from the west, and, after we have proved an influx of warm water along the east coast of the White Sea, that cold water flows out along the west coast, continuing thence along the north coast of the land toward the west, (as a counter-current to the equatorial stream which disappears thereabouts in the high sea.) But we have thus far no direct observations to prove the correctness of this assumption. They are yet to be procured by the energy of our navy and sea-going people.

Reinike's researches (Hydrographische Beschreibung der Nordküste Russlands, 1850, vol. i, p. 23) go only to a depth of five fathoms, at which he found the temperature always agreeing with that of the surface. Our own observations gave the same result. What we know thus far is that there are in the mouth of the White Sea violent currents, especially in the eastern half which is generally avoided, and that on the western coast they attain a velocity of two to four and a half nautical miles per hour. (Lütke Viermalige Reise, 1828, i, pp. 115, 175, and 176.)

The flood-tide reaches Cape Gorodetzkoj from Wardö in seven hours, sidereal time. On the west coast of the neck of the White Sea the current is said to change under the influence of the tide within twelve hours successively to all points of the compass in their regular order, running southwest at the beginning of the ebb-tide, then west, and at full ebb northwest; with the change of tide, east, then south, and lastly at high water again southwest. (Lütke, besides in other places, vol. ii, pp. 174 and 190.) If such is really the case, it must be assumed that, independent of these periodical motions at the surface, the great volume of the water flows in that direction, which appears to be indicated by the thermometer.

Should there really, as seems to be the case, be no influx of cold Polar water into the White Sea, then the sub-surface temperature of 41° observed by us in July is an evidence of the great power exercised by insolation even under the Arctic Circle, as the mean annual temperature of the air at Archangel does not exceed 34°. Although the White Sea is comparatively shallow, bottom is stated not to have been reached in the center with 150 fathoms of line.

I willingly admit that our visit to Nova Zembla in the summer of 1870 was favored extraordinarily as regards temperature, quite as much as Palliser's and Johannesen's visits in the summer of 1869. We even saw no ice at all.* But this does not change anything in the certain result that the Gulf Stream can under the meridian of Kolgujev maintain nearly the same temperature which it has in the North Atlantic Ocean off the Lofotes.

It is self-evident that in 1819, when Lazarev found the entire west coast of Nova Zembla beset with ice, and in 1821, when Lütke, as late in the season as the middle of August, was prevented by the ice from reaching the Kostin Schar, where we encountered no difficulty at all, the branches of the Gulf Stream must have been affected in their temperature uncommonly by the ice drifted into them.

In years when, for instance, the mouth of the White Sea gets clear of the drift-ice late, so that the ice does not disappear before the end of June, instead of the middle of that month, as generally is the case, (Reinike, ii, 34, and Archangel Sbornik, i, 1, 1863, p. 57,) the temperature of the Kanin stream attains its full height probably much later in the season. The prevalence of winds, but especially an uncommon pressure of the Polar stream, may also sometimes dislodge the Kanin stream considerably. But all this cannot change anything in the main facts.

The Gulf Stream, on its slow course from the coasts of Norway to Kolgujev, is subject to numerous depressing influences. As we find at both these places the same temperature of its water, there remains, should not hereafter an influx of warm water from the interior of our planet at the bottom of the sea be proved,

* In 1734 Lieutenant Murawiev was equally favored in the Kara Sea, while much ice was ound there in the succeeding years.

no other source of compensation for the amount of heat which is lost on the way, except the direct action of insolation.

The influx of warmer sweet waters from the main can only have an indirect influence, as we have shown that the much greater part of the north coast of Russia is washed by Polar water; the warmer sweet water could, therefore, only affect the colder coast water insomuch as to prevent a too depressing contact with and admixture of the latter with the warm waters of the Gulf Stream.

We have before us a complication of coöperating agencies, each of which, it is true, might be computed mathematically; nevertheless it will be a long time before physical geography will place within our reach all the elements necessary in order to decide, in the case of a temperature of Arctic water of 36° and less, whether and how far it is due to the Gulf Stream.

* * * * * * *

II.—CAPTAIN JOHANNESEN'S CIRCUMNAVIGATION OF NOVA ZEMBLA IN THE SUMMER OF 1870.

[Captain Johannesen's cruise in 1870 has been briefly noticed on page 191. The following is additional from verbal statements made by him to Mr. von Heughlin, published in the January number of the Geographische Mittheilungen for 1871.—HYDROGRAPHIC OFFICE.]

The Arctic Ocean north of Nova Zembla in the summer of 1870 was remarkably free of ice. Firm ice was not seen as high as 75° 50′ N. and 79° E.

The position of Cape Nassau differs considerably from that heretofore assumed, as also the trend of the coast from there to Cape Vlissingh, the easternmost point of Nova Zembla. Johannesen places the former in latitude 77° 08′ N., longitude 71° 00′ E.,* that is, northeast of the Ice Cape of the charts. It terminates a high plain covered with snow. A great glacier, thirty or forty miles southwest of Cape Nassau, *(Cape Mauritius, Hydrographic Office,)* extends far into the sea, falling off perpendicularly. The three islands southwest of the cape are placed on the present charts too far to the south and west; there are a number of small islets around and between them.

The northeastern coast of Nova Zembla trends from Cape Nassau *(Mauritius)* southeasterly, and has no considerable bights or headlands; the distance to Cape Vlissing *(Hooft-Hoek, Hydrographic Office)* is only 30 to 40 nautical miles. Johannesen sailed along this coast between the 3d and 9th of September without encountering ice.

The sea east of Nova Zembla is deep; one mile from the shore bottom was not reached with 50 fathoms of line. Walrus are abundant in this region, but reindeer appear to be rare on the coast; the Admiralty Cape may be assumed as their northern limit. The northern part of the island is extremely dreary; it is sandy and full of stones, and even mosses will not thrive.

The stream flowing with great rapidity along the north coast of Nova Zembla, in an east by north direction, meets, three miles northeast of Cape Nassau,

---

* Captain Johannesen misnames the two capes of which he speaks. His Cape Nassau is Cape Mauritius of the charts, and his Cape Vlissing is Hooft-Hoek, the next point northeast of Cape Vlissing. Cape Nassau is pretty well established in latitude 76° 40′ N., and longitude 62° 55′ E.—HYDROGRAPHIC OFFICE.

(Cape Mauritius,) another stream setting at Cape Vlissing *(Hooft-Hock)* from south to north. They cause there violent overfalls, in which Captain Johannesen saw very numerous fish and animals of a lower order never seen by him before; they were of various forms and colors, none more than half a yard in length.

About midway between Cape Vlissing and White Island banks were found of soft green, bluish, brown, red, and white sand, at a depth of 10 to 20 fathoms. The water there is so sweet that it might have answered for drinking. It contains, in great abundance, strange fish of silver gray color with pointed heads. This species is said to be found only there or in the melted drift-ice, which, however, was rarely seen by Johannesen that summer.

Maximoff Island, of the charts, could not be found.

The deviation of the compass in 76° 48′ N., and 79° E., was ascertained to be 30½° E.

The rise and fall of the tide in 73° 40′ N., 58° 30′ E., was six feet.

Captain Johannesen observed in and off Nova Zembla many species of animals which are not found in Spitzbergen, as, for instance, the black swan.

It is known that the wolf, the white fox, the common red fox, and two species of leming are indigenous to Nova Zembla. Johannesen assures us that he has seen the same in the Ice Fiord of Spitzbergen, and in Walter Thymen Strait. If so, an annual connection by ice between Spitzbergen and Nova Zembla is probable. Captain Ulve considers the reindeer of Nova Zembla a species different from that of Spitzbergen; the former is said to have longer legs, and its meat to be of higher flavor.

Johannesen, as well as Ulve, found at Cape Nassau, and on the Admiralty Peninsula, glass buoys and pieces of fishing-tackle from the Lofotes.

[The following accounts of five other cruises of Norwegian fishermen, in the summer of 1870, are from the March number of the Geographische Mittheilungen of 1871; that of Captain Ulve has been noticed preliminarily on page 190 of this volume. Dr. Petermann considers the results of these voyages the most important obtained thus far toward the solution of the Polar question. There were during that season altogether 60 Norwegian ships in the European Arctic Sea, and all of them appear to have been very successful.—HYDROGRAPHIC OFFICE.]

III.—CAPTAIN T. TORKILDSON'S CRUISE IN THE SCHOONER ALPHA FROM MAY 10 TO JULY 13, 1870.

Captain Torkildson left Trondjem May 10, 1870, passed the North Cape May 26th, remained in Busse Sound, near Wardö, May 29th to June 6th, and met the first drift-ice on the 8th of June, northwest of Kolgujev Island, in latitude 70° 24′ N., longitude 46° 01′ E. of Greenwich. After working in an eastern direction through this drift-ice, which he found in places very dense, though much differing in thickness, (from 4 inches to 18 feet,) he did not come again into open water, before the 18th of June, in latitude 70° 17′ N., longitude 52° 16′ E., but then made a quick passage to the coast of Nova Zembla and the Kara Strait, through which he sailed on the 24th of June, notwithstanding the great masses of ice which he found there.

There was at this time very considerable ice in the Kara Sea, some very thick and of great strength, and on the 26th of June, east of Waigatsch Island, the vessel was beset by vast masses of it, of a thickness of two to three fathoms above, and eight to thirty fathoms below the surface of the sea; but the rapidly increasing temperature of the air, and also that of the water brought already to bear their influence. From the 8th to the 23d of June the water had been, with a few exceptions, throughout below 32°, frequently 29°, and also, the air had been of a low temperature, from 34° to 39°, but then the latter began to rise; on the 20th it was 39°, on the 22d as high as 42°.4, remaining to the 26th between 39° to 41°; some observations even showed 49°.1. From the 26th of June the temperature of the air and of the water rose steadily, reaching on the 1st of July as high as 56°.3 (water) and 41°.7, (air,) and in the mean of that day to respectively 52°.9 and 36°.7. In the diary it is stated, "the warm air has considerable influence upon the ice, but it is nevertheless still impossible to proceed."

On the 2d of July, from 3 to 5 p. m., (still beset in the ice east of Waigatsch Island,) there was a thunder-storm and violent rain, with a temperature of the air at 63°.5; and on the evening of the 3d again a thunder-storm, after which the ice parted, and Captain Torkildson could resume his cruise, steering first for the south end of Waigatsch Island, and then running along the land southeast into Kara Bay, penetrating to its head, where, however, he lost his vessel on the 13th of July, (in latitude 68° 39′ N., longitude 67° 58′ E.) The cause and the circumstances of the wreck are not recorded in the journal.

From the 5th to the 13th of July the temperature was high along the entire coast between the Jugor Strait and the Kara Bay; the daily means of the air being respectively 54°.1, 54°.5, 52°.5, 53°.6, 49°.1, 49°.8, 48°.6, and 45°.7; and of the water, 43°.2, 40°.1, 40°.1, 46°.4, 40°.6, 41°.4, 41°.2, and 42°.4; the maximum as high as 48°.4. There were thunder-storms with rain, and at times with lightning also, on the 6th, 7th, 9th, and 10th of July.

IV.—CAPT. T. TORKILDSON'S CRUISE IN THE SCHOONER ICELAND, FROM JULY 22 TO AUGUST 28, 1870.

After the wreck of the Alpha Captain Torkildson took command of anothre schooner, the Iceland, but as he had lost his thermometers he could not make further observations. Sailing from the 22d of July to the 8th of August along the eastern shore of the Kara Sea, he came as far as White Island, encountering but little drift-ice, frequently only single flakes, and north of the parallel of latitude 73° N., no ice at all. The current was setting mostly to the north and northeast; there was again a thunder-storm on the 29th of July, in latitude 72° N.

From White Island Torkildson sailed southwest back to the Kara Strait, where he arrived on the 17th of August; only between latitudes 72° and 73° he met, in the vicinity of the coast, some few ice-flakes. There was no ice to be seen in the Kara Sea, and it had disappeared completely east of Waigatsch Island, where in the end of June and the beginning of August he had been beset in the Alpha by vast masses. There was also no trace of the ice left west of Nova Zembla between latitudes 70° and 72° N., and after a very quick passage he came to anchor at Tromsö on the 28th of August.

V.—CAPTAIN C. A. ULVE'S CRUISE IN THE SCHOONER SAMSON, APRIL 16 TO SEPTEMBER 3, 1870.

[Captain Ulve's cruis is already preliminarily noticed on page 190 of this volume.—HYDROGRAPHIC OFFICE.]

Captain Ulve left Tromsö as early as April 16th, made a quick passage around the North Cape, and met the first drift-ice April 20th, in latitude 69° 29′ N., longitude 44° 05′ E. of Greenwich, 60 nautical miles north of Kanin Noss; the temperature of the air which, when sailing from Tromsö, had been 40°.3, fell to 24°.6, that of the water from 39°.9 to 29°.3. With violent gales from N. N. W. he approached Kanin Noss within 30 miles; the drift-ice extended from that cape northeast toward Nova Zembla, and became, toward the east, so thick that it prevented Captain Ulve from sailing for the Kara and for the Jugor Strait; he therefore kept northeast and north-northeast, cruising more than six weeks, from April 20th to June 3d, between Kanin Noss and the Geese Land, the westernmost foreland of Nova Zembla. He had to contend repeatedly against violent gales, high seas broke over the vessel, and the water froze when touching the deck; the thermometer fell steadily until, on the 30th of April, it reached the minimum of 13°.8 (air) and 28°.4, (water.) The temperature of the air remained low throughout the month of May, mostly between 34° and 23°, rarely above 32°; the water between 34° and 30°.

Toward the end of May the ice diffused perceptibly, and was melting at a temperature slightly above the freezing point. On the 2d of June, in sight of Nova Zembla, it ceased entirely; Captain Ulve found an extensive open coast-water, and could follow the coast northward to Matotschkin Shar which, however, on June 7th, was still blocked by ice, as also the bights north of it to Ssuchoi Noss contained, on account of the prevailing westerly winds, much ice. Captain Ulve then cruised, from June 7th to the 2d of July, near the coast between 73° and 74° N., especially near Ssuchoi Noss, hunting walrus and seal; the temperature of the air remained during that time, in the mean, at about 35°.5.

In the middle of June the shore-ice of the bays began to loosen and to drift away from the land, but the prevailing west winds drove it again to the shore, piling it so that at one time, off Ssuchoi Noss, the ship was nearly encased to the rail, and the keel lifted five feet. Toward the end of the month the wind blew mostly from the southwest, raising the temperature considerably, from 34°.2 on the 27th, to 40°.5 on the 28th, 42°.8 on the 29th, 47°.3 on the 30th, and 50°.7 on the 1st of July; at 4 p. m. of the latter day the thermometer stood at 56°.1. After landing on the 30th of June on Goat Cape, at the entrance to Matotschkin Shar, (Matthew Strait,) Captain Ulve sailed north, along a coast now entirely free from ice, passing Ssuchoi Noss on the 2d, Cross Bay on the 5th, and Cape Schanz on the 7th of July. On the 8th and 9th, in latitude 74½° N., the wind blowing very strong from the E. S. E., at a temperature of 54°.5, several thunder-storms occurred, accompanied by vivid lightning and rain in uncommonly heavy drops, and closing with a continuous roaring of thunder from all directions.

Beating onward Captain Ulve reached, on the 19th of July, the Hump Islands, near latitude 76° N., where much drift-wood (larch and pine) was found, as also fishing utensils such as used on the Lofotes, an important observation which confirms undisputably the extension of the Gulf Stream to this far coast of Nova Zembla. On the 23d of July he passed the Pankratjew Islands, of which there are many more than shown on the charts, and north of them he made on the following day, in latitude 76° 02′ N., a bay which he named Palliser Bay. On the 31st of July he came to latitude 76° 34′ N., longitude 62° 34′ E., close to Cape Nassau; the temperature of the air was there (the mean of July 31st) 33°.6, that of the water 33°.1.

Along this northern part of the coast of Nova Zembla, from Ssuchoi Noss in latitude 73° 40′ N., to Cape Nassau, in 76° 40′ N., there was everywhere navigable water, with but very little drift-ice; and at Cape Nassau no ice at all was seen; the current sets there to the northeast, still with so great a force "that is is hardly possible to obtain accurate observations for position." In 76° 15′ N. twenty great icebergs were met in the open water close to the shore, one of them grounded in 40 fathoms.

From Cape Nassau Captain Ulve sailed on the 1st of August northwest, to latitude 76° 47′ N., longitude 59° 17′ E., a distance of 47 miles, without seeing a trace of ice; the temperature of the air, as well as that of the water, increased; the former to 35°.8, the latter to 34°.7. From this, his northernmost point, he sailed south, intending to pass through Matotschkin Shar into the Kara Sea. During the last two weeks the sea had become so free from ice that he made against the strong current, 120 miles, from Cape Palliser to the Admiralty Peninsula, in one day, the 3d of August, and reach Matotschkin Shar on the 6th, where he again landed on Goat Cape. There he found most brilliant flowers and grass 18 inches high; he had not seen any ice from latitude 76° 47′ N. down to latitude 73° 15′ N., but the coast had grown remarkably verdant; the daily mean of the temperature of the air had risen by degrees to 45°.0, that of the water to 41°.7.

On the 7th and 8th of August he sailed, without any difficulty, through Matotschkin Shar, which now was entirely free from ice, and on the north shore of which he saw a herd of reindeer, counting more than 50 head; he also discovered a considerable sheet of water inland of the northern shore, but could not make out whether it was an arm of the sea or a lake. The mean temperature of the water in the strait was 38°.1, that of the air 41°.9.

In the Kara Sea there was, on the 8th of August, no ice to be seen; the first was met drifting in a southwest direction, after the vessel had sailed 140 miles through the greater half of that sea; the temperature of the water east of the strait at first was 43°.2, then between 39°.0 and 36°.5, but in the vicinity of the ice, and on the banks, it fell to 34°.2; on the latter there are generally numerous walrus. When in the center of the sea Captain Ulve turned south, beating among some flakes of ice; he saw no more after turning again east, and also none when sailing northeast to within 40 miles of White Island.

In 73° 43′ N., 68° 28′ E., on the 21st of August, there was still no trace of ice; the temperature of the water had increased gradually to 41°.9, that of the air remaining the same as before, and the sea contained but little salt. From that point Captain Ulve sailed, in one single day, the 22d of August, across the entire breadth of the sea, making 150 miles, still without meeting ice, the temperature of the water being 37°.2, and the current prevailing in a northwest direction. There was also no ice at the Puchtussow Islands.

From these latter Captain Ulve sailed on the 23d southeast 160 miles, and on the 24th southwest 136 miles to the Kara Strait, without being able to discover traces of ice. The immense masses which, in May and June, had beleaguered the western shore north and south of latitude 70°, had now also disappeared entirely. The temperature of the sea was, in the Kara Sea, on the 23d, 40°.6, and on the 24th, 38°.8; in the Kara Strait, on the 25th, 38°.8; on the home passage from the Kara Strait to Tromsö, on the 26th, 40°.8; the 27th, 42°.1; the 28th, (off Kolgujev Island,) 41°.9; the 29th, 41°.9; the 30th, 43°.9; the 31st, 45°.5; the 1st of September, 45°.7; the 2d, 46°.6; and the 3d, 47°.8 On that day the vessel came to anchor off Tromsö.

VI.—CRUISE OF CAPT. F. E. MACK (SCHOONER POLAR STAR) FROM APRIL 4 TO SEPTEMBER 8, 1870.

Captain Mack left Tromsö on the 4th of April, passed the North Cape April 10th, and arrived on the 15th of the same month at Vardö, which he left again on the 25th, steering east. On the 28th of April, in latitude 69° 36′ N., longitude 45° 56′ E., 50 miles west of Kolgujev Island, the first ice was met, but only an inch in thickness.

In this region, north and south of the parallel 70° N., between the meridians of Kanin Noss and Geese Cape, he was, like Captain Ulve, beating between the ice throughout the whole of May, without being able to penetrate farther east. The air kept below the freezing point, ranging between 32° and 14°, (the lowest observed;) the water between 27°.5 and 29°.8; the temperature of the air rose slightly above the freezing point on the 25th. On the 29th of May the vessel was headed for Kanin Noss, where she came to anchor on the 31st; from there Captain Mack sailed east along the Russian coast and around Kolgujev Island. On the 21st of June, the vessel being between this island and the Russian coast, the ice opened east at a temperature of the air of 35°.1, and of the water of 31°.1. From the 1st to the 21st of June, around Kolgujev Island between the parallels 67° and 70° N., the air had, on the average, been but a few degrees above the freezing point, from 50°.7 (the maximum) to 27°, (the minimum;) the temperature of the sea at the surface between 34°.7 and 29°.3.

Captain Mack now pressed through the drift-ice, east along the Russian coast, and on the 22d, not far from Sengeiski Island, in about 51° E., he came into open water; a strong current was running there to the west, containing considerable sweet water, undoubtedly from the Petchora. On the 27th the vessel was off the west cape of the mouth of the latter river, 15 miles from which a quantity of drift-wood was met, some 7 inches in thickness and 28 feet long.

The passage from there to Britwin Island on the southwest coast of Nova Zembla was a very quick one, and through a sea completely free of ice, as also the passage along the west coast to Matotschkin Shar. The distance from Britwin Island to Moller Bay, 170 nautical miles, was made in a single day. Nowhere was ice seen; the temperature of the sea from the Petchora mouth northward increased steadily, the daily means being in succession, 36°.3, 37°0, 39°.9, 42°.1, and 48°.2, the last in Moller Bay on the 3d of July. From there to Matotschkin Shar it was decreasing gradually, to 37°.4, at the entrance to the latter on July 4th.

On the 5th of July Captain Mack entered Matotschkin Shar; he could, however, penetrate it but 20 miles, about a third of its length, when further progress was blocked by ice; the current at that time was found to set from east to west.

He therefore retraced his way and continued the cruise north along the coast, arriving on the 8th of July at the Admiralty Peninsula, in latitude 75° N. From the mouth of the Petchora, in latitude 69° N., to the Admiralty Peninsula, in 75° N., the sea and the waters on all coasts of Nova Zembla, thus traversed, had been found by Captain Mack completely free of ice, and only at the latter place, near which not less than 14 sailing vessels and two steamers were then fishing, some ice was again met. There were thunder and lightning in this latitude on the 8th and 9th of July.

After staying a few days near the Admiralty Peninsula Captain Mack sailed on the 14th again for Matotschkin Shar, arriving at the entrance on the 18th; he now found it not only open, but nearly entirely free from the ice, and made so quick a passage through it that he entered Kara Sea on the 19th. He then sailed south along the east coast of Nova Zembla as far as Waigatsch Island, which he reached on the 25th. Immediately south of Matotschkin Shar drift-ice was beleaguering the coast to a distance, east, of 20 miles, which, however, soon decreased in width, and ceased entirely in about latitude 72½° N. South of that parallel warm west winds were prevailing of a maximum temperature of 66°.9, (on the 21st of July in latitude 71½° N.,) accompanied by thunder.

Captain Mack now cruised from the 26th of July to the 21st of August, between Waigastch Island and White Island, that is, in the southeastern half of the Kara Sea, and especially on the fishing banks. During all this time he saw only three times detached flakes of ice; on the 26th of July, in latitude 71° N.; on the 27th, in latitude 71½° N.; and on the 15th of August, in latitude 72½° N. The temperature of the water over the deeper parts of the Kara Sea remained, on the average, above 36°.5, and over the shallows between 36°.5 and 34°.3. The following is recorded in the journal on the 13th of August, in latitude 73° 42′ N., longitude 66° 04′ E.: "There is ice about 20 miles from White Island, but, judging from the movement of the sea, none appears to be in a northeast direction within a great distance, and nothing is to prevent a passage to the Obi."

After remaining at anchor on the south coast of Nova Zembla from the 22d to the 27th of August, Captain Mack sailed home for Tromsö, where he arrived on the 8th of September, without having met ice.

One of the most important results of this cruise is the establishment of the fact that there was west of Kolgujev Island, between latitudes 68° and 70° N., from the 28th of April to the 21st of June, a thick ice-belt, while the sea east of that island, along the west coast of Nova Zembla, between latitudes 68° and 75° N., was from the 22d of June completely free of ice.

VII.—CAPT. P. QUALE'S CRUISE IN THE YACHT JOHANNA MARIA FROM JUNE 4 TO SEPT. 15, 1870.

The yacht Johanna Maria, under Captain Quale, and navigating officer A. O. Nedrevaag, left Vardö on the 4th of June, sailing northeast instead of east, as the above-named vessels, but in this direction ice was soon met, viz, on the 6th, in latitude 72° 04′ N., longitude 40° 52′ E. It appears, from all the cruises, that the limit of drift-ice extends from Kanin Noss first northeast to about midway between it and Nova Zembla, that is, from latitude 68½° to latitude 71° N., then turns north to about 72° N., whence, in the beginning of June, it turns west. The northeastern course was followed until the 10th of June, when, as no end of the ice belt could be seen, the vessel was steered south in the direction of Kanin Noss to latitude 70° N., thence east to Kolgujev Island, and from the latter northeast toward Nova Zembla.

The Kolgujev ice-belt was found of the same extent as described by Torkildson, Ulve, and Mack, but it was now so loose, and the ice so diffused, that Quale could without difficulty break through it between the 13th and 20th of June, reaching the coast of Nova Zembla on the 22d. There was only a little drift-ice on the coast in latitude 71° N., but north of the latter, up to Matotschkin Shar, no trace of it; this strait, however, was on the 1st of July still blocked. After sailing as far as Ssuchoi Noss, Captain Quale turned again south, keeping along the coast in order to pass through the Jugor Strait into the Kara Sea.

Nedrevaag's observations during this part of the cruise prove the existence of a cold stream, running north, close to the southwestern coast of Nova Zembla, which already had been observed by Lütke, and of late by Middendorf.

This cold current, which extends from the Kara Strait along the coast, had, up to the Geese Foreland, in July, a temperature of not above 41°; at the Geese Foreland 47°.8 was observed by Nedrevaag, agreeing with Mack's observation of 48°.2.

Captain Quale reached Kara Strait as early as the 9th, and Jugor Strait on the 10th, without seeing ice. Off the Kara Strait there were thunder-squalls from the N. N. E., the temperature of the sea increasing from 41° to 58°.6, and remaining up to Jugor Strait, on the average, at 54°.5 and 52°.3.

After passing Jugor Strait Captain Quale followed the coast to Kara Bay, south of the parallel 69° N. Keeping on the same course as Torkildson, Nedrevaag observed there, agreeing with the latter, a comparatively warm furrow of water not quite as high tempered, (Torkildson had observed a week earlier 48°.4,) but still 44°.1; the difference is accounted for by a quantity of ice which had in the mean time drifted from the northeast to the vicinity of the coast.

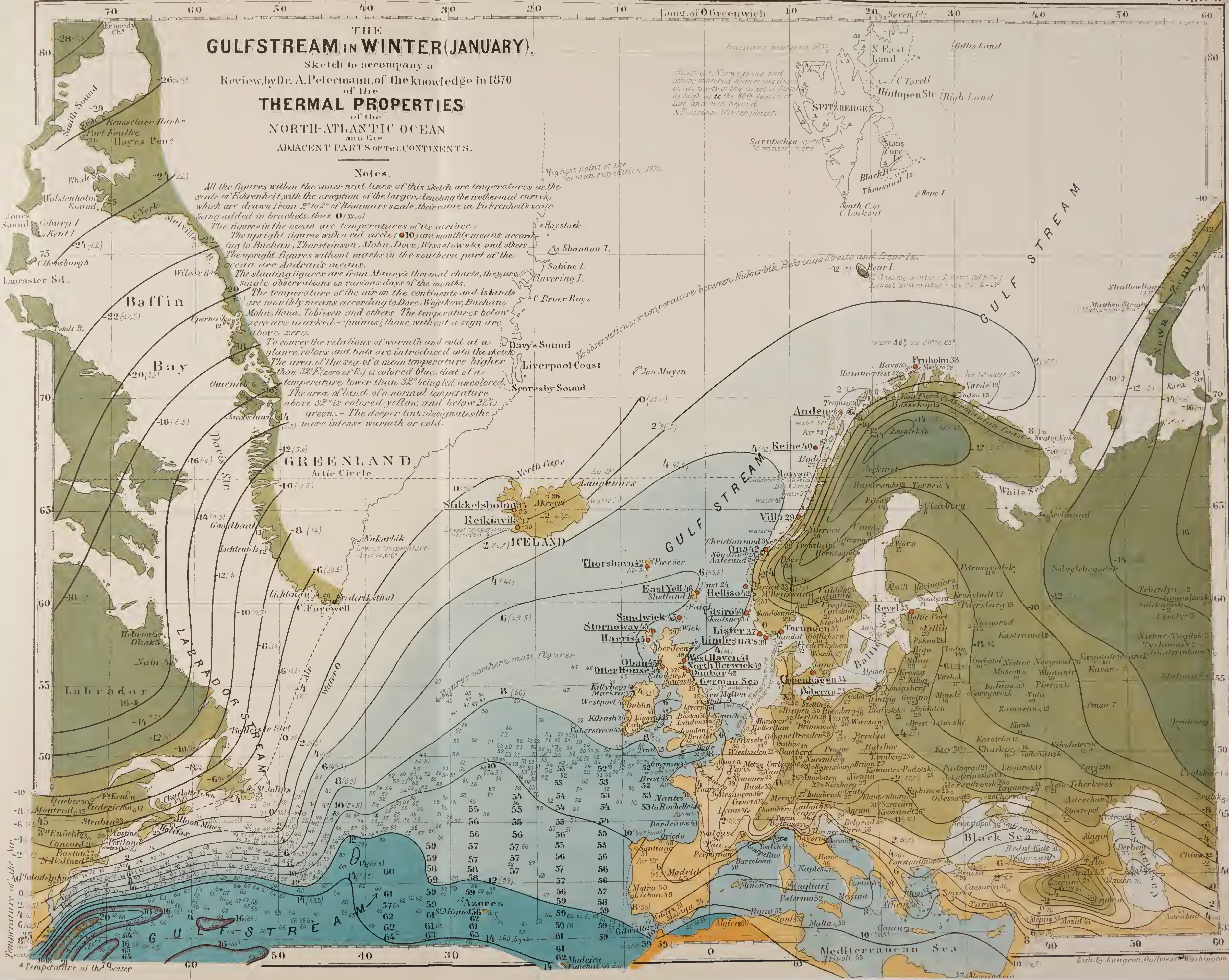
From his southernmost point in 68° 55′ N., Quale steered, on the 17th of July, along the eastern shore of the Kara Sea to White Island, and beyond it to latitude 75° 27′ N., which he reached on the 12th of August. In this stretch of 6½ degrees of latitude but a few detached flakes of ice were met with between latitudes 69½° and 72½°, and north of this but at one single place, in latitude 75° N. The temperature of the sea decreased from 38°.7 and 41° in the southernmost part of the Kara Sea, toward the center of it gradually to 36°.5 and less, in one spot even to 28°.4; beyond latitude 72° N., however, it increased again to 42°.1 in latitude 74½° N.

From his northernmost point (75° 22′ N., 72° 15′ E.) Quale sailed still farther east to 74° 35 E., beyond the meridian of the mouth of the Obi, without perceiving ice, and observing on August 14th a temperature of the sea of still 40°.6. From thence he crossed the Kara Sea from east to west, making in two days not less than 220 miles, and meeting ice but at one place. The temperature of the sea was, in the mean for the two days, (15th and 16th of August,) 37°.4.

Beating southward along the east coast of Nova Zembla, he arrived, on the 21st of August, at Matotschkin Shar, passed through it on the 26th and 27th, sailed along the west coast to Cape Stepowy in latitude 74¼° N., and turned then homeward, making the passage from Matotschkin Shar to the North Cape, a distance of 560 miles, in four days. No ice was seen. On the 16th of September he arrived back at Tromsö.

Plate I.

THE GULFSTREAM IN SUMMER (JULY).
Sketch to accompany a Review, by Dr. A. Petermann, of the knowledge in 1870 of the THERMAL PROPERTIES of the NORTH-ATLANTIC OCEAN and the ADJACENT PARTS OF THE CONTINENTS.
Notes.
The figures in the ocean are temperatures of its surface.
GULF-STREAM
POLAR STREAM
LABRADOR STREAM
GREENLAND
ICELAND
SPITZBERGEN
Baffin Bay
Davis Straits
Labrador
Arctic Circle
Black Sea
Mediterranean Sea
White Sea
Baltic Sea
German Sea
Nowaja Zemlja
Azores
Madeira
Long. of Greenwich
Lith by Langran Ogilvie


THE
GULFSTREAM IN WINTER (JANUARY).
Sketch to accompany a
Review, by Dr. A. Petermann, of the knowledge in 1870
of the
THERMAL PROPERTIES
of the
NORTH-ATLANTIC OCEAN
and the
ADJACENT PARTS OF THE CONTINENTS.
Notes.
All the figures within the inner neat lines of this sketch are temperatures in the scale of Fahrenheit, with the exception of the larger, denoting the isothermal curves, which are drawn from 2° to 2° of Réaumur's scale, their value in Fahrenheit's scale being added in brackets, thus 0 (32,0)
The figures in the ocean are temperatures of its surface:
The upright figures with a red-circle (10) are monthly means according to Buchan, Thorsteinson, Mohn, Dove, Wesselowski and others.
The upright figures without marks in the southern part of the ocean are Andrau's means.
The slanting figures are from Maury's thermal charts, they are single observations on various days of the months.
The temperature of the air on the continents and islands are monthly means according to Dove, Wojeikow, Buchan, Mohn, Hann, Tobiesen and others. The temperatures below zero are marked — (minus); those without a sign are above zero.
To convey the relations of warmth and cold at a glance, colors and tints are introduced into the sketch. The area of the sea of a mean temperature higher than 32° F. (zero of R.) is colored blue, that of a temperature lower than 32° being left uncolored. The area of land of a normal temperature above 32° is colored yellow, and below 32° is green. — The deeper tints designate the more intense warmth or cold.
GULF STREAM
LABRADOR STREAM
GREENLAND
ICELAND
SPITZBERGEN
Baffin Bay
Labrador
Black Sea
Mediterranean Sea
White Sea
Nova Zemla
Long. of 0 Greenwich
Temperature of the Air
Temperature of the Water
Lith. by Langran, Ogilvie & Washington D.C.

D - 7.

DOBBS BROTHERS
LIBRARY BINDING CO., INC
ST AUGUSTINE, FLA.

SEP '68

LIBRARY OF CONGRESS
0 019 639 422 9